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Petroleum Technology

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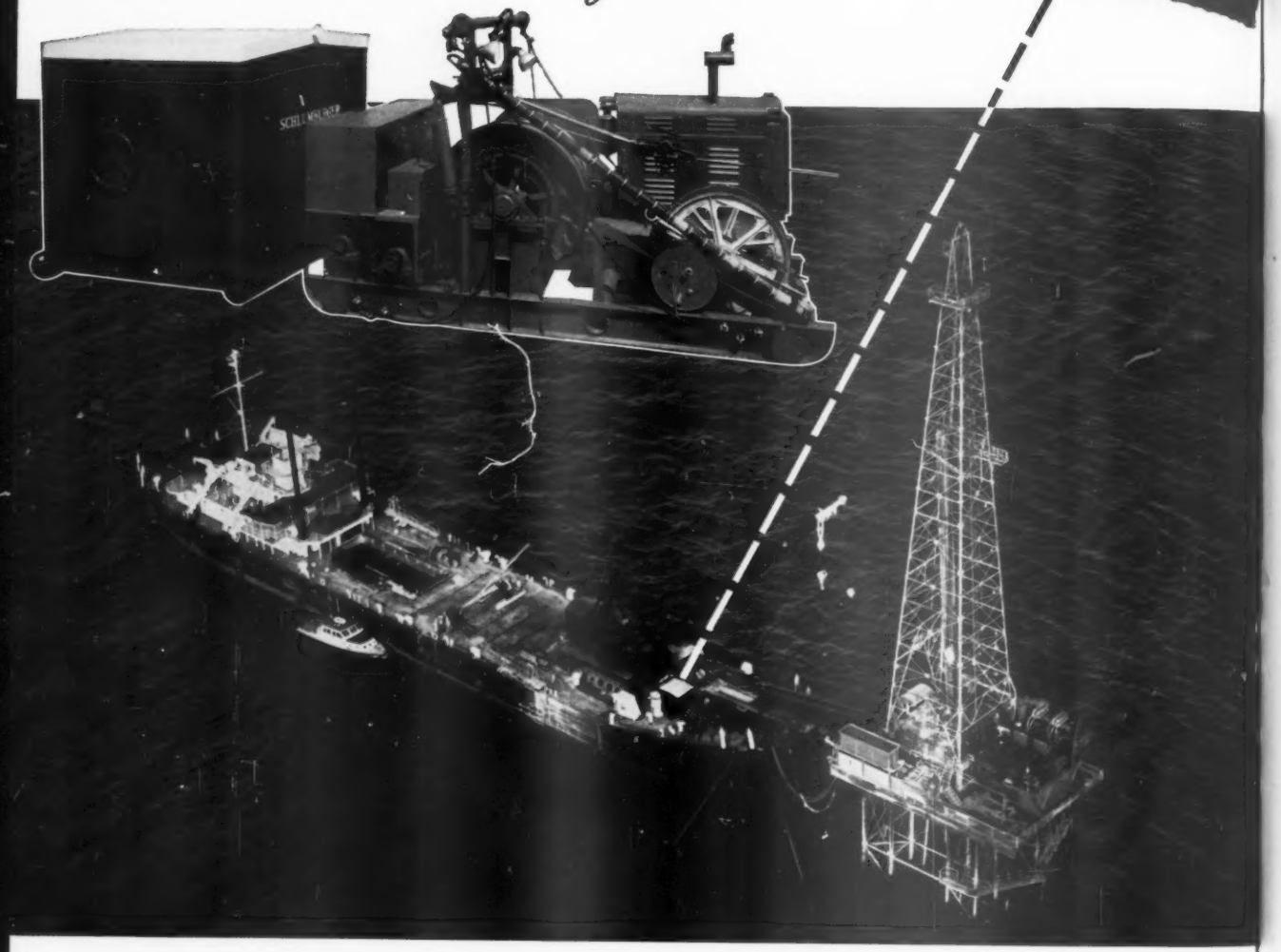

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Editorial Comment

LLOYD E. ELKINS

STANOLIND OIL & GAS COMPANY

TULSA, OKLAHOMA

SUBSCRIBING TO THE JOURNAL

WE ARE keenly aware of the fact that many members of AIME who desire to be affiliated with the Petroleum Branch did not receive a copy of the January *Journal*. The reason for this is that those members did not indicate their desire to receive the Journal. A post card was mailed to petroleum members by the New York office of AIME last November, which requested that you designate which of the three monthly journals published by the Institute that you wish to receive. Those members who had not returned their cards by the January mailing did not receive their copy.

Those of you who receive this (February) issue of the *Journal* can be very helpful in this respect. If you learn of a fellow AIME member who desires to receive the *Journal*, but is not doing so, suggest that he notify AIME headquarters in either New York or Dallas. The address: 29 West 39th St., New York; 601 Continental Building, Dallas.

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CONFLICT WITH ASME FALL MEETING DATES

FOR the past several years the ASME Petroleum Division has scheduled their annual meeting during the same week that our fall meeting has been held. Some of their membership has complained about this conflict and it may be that some of our members would be interested in attending both meetings.

In order that these conflicts may be eliminated starting in 1950, your branch officers and executive committee have advised the ASME as to our policy for setting meeting dates for our fall meetings involving the membership east of the Rocky Mountains. It is as follows:

> "Since its formation in 1924 (excluding only the war years, 1943-45) the Petroleum Branch of the AIME has held a major meeting in the Southwest in the fall of each year. Of the 21 meetings, 20 fell within the dates of Sept. 30 to Oct. 31, and of these 20 meetings, 15 were held within the dates, Sept. 30 to Oct. 12. The Branch Executive Committee feels that this consistent selection of the last few days in September, and the first several in October is a tradition deserving of respect, and is moreover a desirable practice in maintaining coordination with other meetings and affairs of the Branch and of the AIME, and expresses the intention of following the same practice in future normal years. The Branch Chairman is authorized to announce this policy, and the Branch Secretary is instructed to inform all interested organizations as far in advance as possible whenever it might later appear that a deviation from this policy will be in the best interests of the AIME petroleum membership."

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BUDGETING AND ACCOUNTING BY BRANCHES

I WISH to publicly commend the Finance Committee of the AIME for its new policy adopted this year in setting up their budget system and systems of cost control for the three individual branches. This will make available to both the Board of Directors and the Branch Councils information which will permit the ready evaluation of the cost of services rendered to the memberships of each of the branches.

We of the Petroleum Branch have for some time felt that the cost control system used by the Board of Directors was inadequate to readily evaluate the cost for operating each of the previously established eleven divisions of AIME. We have also expressed the belief that we could get out and get advertising revenue if we had our own publication and if we had the incentive brought about by having available more funds for expansion if we raised those funds.

The Board of Directors has not, and probably will not, delegate to the branches complete authority over the distribution of Institute funds; however, I am confident that under the new system of budget and cost control by branches we will be able to secure all funds necessary for worthy expansion and activities providing we can show that we are raising the appropriate funds required.

The Board of Directors and the Finance Committee have set up the system. It is now up to our Officers, our Branch Council, and each of our members affiliated with the Petroleum Branch to do all in our power to increase our membership, contribute to our *Journal*, and let the industry at large know that there is something to be gained from advertising in the *Journal*. ★ ★ ★

PETROLEUM BRANCH OFFICERSHIP ELIGIBILITY LIST

ARTICLE VIII of the By-Laws adopted March 20, 1947 provides that:

". . . To be eligible for election to the Executive Committee a member shall have had wide experience in the affairs of the Branch . . . "

". . . To be eligible for Chairman a member shall have had three years of active service in the Branch, at least one of which shall have been as Chairman of a standing of special committee or as a member of the Executive Committee . . . "

". . . To be eligible for Vice-Chairman a member shall have had two years of active service in the Branch, at least one of which shall have been as chairman of a standing or special committee, or as a member of the Executive Committee, or a Chairman of a Local Section . . . "

The list below is of members who meet the specific provisions of eligibility for election to Chairman or Vice-Chairman. No attempt has been made to distinguish those who meet the non-specific portion of the eligibility requirements, i.e., "wide experience" and "three years of active service". Data after each name represents the year and type of service, according to the code below.

The Pacific Petroleum Chapter has been considered a Local Section, within the intent of the By-laws. The list may be incomplete with respect to the earliest years of the Branch (1922-27), as full records on that period are not available. Please call any errors or omissions to the attention of the editor.

POSITION CODE

AC	Associate Branch Chairman
Ch	Branch Chairman
CLS	Chairman, Local Section
DT	Division Treasurer
EC	Member, Executive Committee
Ec	Chairman, Education Committee
EE	Chairman, Engineering Education Committee
ER	Chairman, Engineering Research Committee
Ge	Chairman, Geophysics Committee
Lc	Chairman, Lucas Fund Committee
Me	Chairman, Membership Committee
Nom	Chairman, Nominating Committee
PE	Chairman, Production Engineering Committee
PG	Chairman, Production Geology Committee
PP	Chairman, Papers and Programs Committee
PR	Chairman, Production Review Committee
Pro	Chairman, Progress Committee
Prod	Chairman, Production Committee
PT	Chairman, Production Technology Committee
Pub	Chairman, Publications Committee
RE	Chairman, Refinery Engineering Committee
RVC	Branch Regional Vice-Chairman
SC	Chairman, Special Committee
ST	Branch Secretary-Treasurer
St	Chairman, Stabilization Committee
TE	Transportation Engineering Chairman
VC	Branch Vice Chairman

A - C

Akins, D. W., Jr.
Albertson, M. — PE 35 AC 36 Ch 37 EC 38
Alcorn, I. W. — Me 45 CLS 44 Ch 48 EC 48 49 Nom 49
Ambrose, A. W. — CLS 27 EC 30-35 Ch 28
Andrews, Paul — CLS 49 EC 49
Armstrong, E. B. — CLS 47
Atkinson, Burton — CLS 48
Atkinson, Thomas — CLS 47
Aucoin, Riley — CLS 45
Beal, Carlton — EC 46 ST 46 VC 48 EC 48 SC 47-48
Beams, Robert J. — CLS 48
Beardmore, H. F. — CLS 41 RVC 44 Ch 46 EC 45-46-47
Beecher, C. E. — AC 30 Ch 31 EC 32-37
Bell, John S. — PE 46 CLS 44
Bennett, E. O. — EC 35
Berwald, Wm. B. — CLS 45 EC 47
Bethancourt, Raoul — CLS 49
Blau, L. W. — Ge 43 44
Bradley, R. J. — Ec 48 49
Briggs, Frank L. — Me 49
Brownscombe, E. R. — Pub 48
Buckley, S. E. — CLS 42 PP 42 EC 44-45-47-48-49 AC 44
Bugbee, J. M. — Me 43 CLS 43
Calhoun, J. C., Jr. — Ec 49
Camp, R. W. — RE 32
Carpenter, Charles B. — RVC 46 EC 46 DT 47-48-49
Coberly, C. J. — AC 40 EC 41-42
Corless, G. B. — EC 37-38-39 Ch 38
Covell, K. A. — CLS 38 PE 44
Craft, B. C. — Ed 45 ST 38-39-40 EC 44 PP 44 EC 48-49-50

D - F

Dahlgren, E. G. — PR 47-48-49
Decker, Harold — CLS 47 EC 49-50-51
Dooley, David L. — CLS 47
Duce, J. Terry — Prod 35-36-37-38-39-40-41
Dunlap, E. N. — CLS 49
Earlougher, R. C. — Pub 47 CLS 46
Elkins, Lincoln — CLS 49
Elkins, Lloyd — CLS 45 VC 47 EC 47-49-50 Ch 49
Erwin, E. W. — CLS 43
Estabrook, E. L. — EC 32
Fisher, Eugene A. — CLS 46
Fisher, Gordon H. — CLS 47 Pub 49
FitzGerald, Norman D. — Ec 42-43-44
Fitzgerald, P. E. — CLS 40 ER 42 Me 44 Pub. 46 VC 48 EC 48
Foley, L. L. — CLS 34 PE 36 EC 37 Me 38
Fohs, F. Julius — Ch 25-26
Fowler, Harry C. — EC 36 ER 32
Frick, Tom C. — CLS 47 CLS 49
French, Richard W., Jr. — PT 48

G - K

Garrison, A. D. — ER 41
Gaylord, E. G. — EC 35 Nom 39
Geis, W. H. — AC 38 EC 39-40-41 Ch 39
George, H. C. — EE 30 ST 32
Gill, John D. — EC 45-46
Graybeal, J. W. — CLS 45
Greenidge, S. M. — EC 39
Haider, M. L. — PE 38 Pub 43-44 EC 43-45-46 Ch 45 Nom 46
Halbouty, M. T. — CLS 39 Me 40
Hamilton, R. G. — CLS 43
Hammond, John — CLS 49
Harlan, Don L. — CLS 49
Haynes, W. P. — Prod 43-44
Hayward, J. T. — ER 36
Herald, Frank A. — Prod 33-34
Heroy, W. B. — EC 39-40-41-43
Hess, Robert M. — CLS 45
Higgs, Morton T. — CLS 45
Hill, H. H. — ER 30
Hocott, Claude R. — PP 45 AC 46 EC 46
Holmes, Joseph A. — CLS 47
Huntington, R. L. — ER 37-38
Jackson, Warren J. — CLS 48
Johnson, H. Norton — AC 33
Jones, N. N. — CLS 41
Katz, D. L. — ER 39-40 PP 43 Ed 46-47
Kaveler, H. H. — ER 45 PP 46 EC 46
Kelly, R. B. — EC 37-42 AC 41
Keplinger, C. H. — CLS 37 PE 42 RVC 46 EC 46
Knappen, Russell S. — EC 32-34
Knowlton, D. R. — EC 38 EC 41
Kraus, Edgar E. — PG 46

L-P

Langford, C. M., Jr. — CLS 40
Lilley, E. R. — ST 30 Pub 45
Loomis, A. G. — ER 44
Lovejoy, John M. — Ch 27 LC 32-33-34-35
Lyle, Henry — CLS 48
Manion, Peter P., Jr. — Me 47 CLS 48
Mapes, Clarel B. — EC 33-34
Marsh, H. N. — EC 32-33-36-37-38 Ch 36 Nom 40
Marshall, Dan L. — CLS 47
McCutchin, John A. — CLS 42
McMillan, John — CLS 47
Mercier, V. J. — CLS 49
Miller, Walter — RE 27 to 46 inclusive

Continued on Next Page

THE LATE HARRY C. WIESS RECEIVES CHARLES F. RAND MEDAL

One of the highlights of the San Francisco meeting was the conferring of honors at the annual banquet on February 16, when a total of nine awards and medals were presented.

Among these, the Charles F. Rand Medal was presented posthumously to Harry Carothers Wiess, a recent outstanding figure in the petroleum industry. The presentation was made to Mrs. Weiss in recognition of Mr. Weiss' achievements, with the citation reading in part, " . . . for energy, wisdom, and administrative ability which found expression in major contributions to the economy of the nation and the world; for high courage and vision in services to the petroleum industry; for ceaseless efforts in fostering during World War II the production of strategic supplies; for a greatness of character which showed itself in his many philanthropies and in the respect of all who knew him."

Harry C. Wiess spent almost a working lifetime in the oil industry. A native of Beaumont, Texas, he entered the industry there in 1912 with the Parrafine Oil Company and served this firm until 1917. In that year he became one of the founders and a vice-president of the Humble Oil & Refining Company, and held this post until 1933, directing the refining and sales activities of the company. He was named executive vice-president in 1933, president in 1937, and chairman of the board in May, 1948. He was serving in that capacity at the time of his death, August 26, 1948.

During World War II he was very active in making petroleum and other vital supplies available to the armed forces, and the posthumous presentation of the Rand Medal is partly in recognition of this service. He was a member of the general committee for the Southwestern Area of the Petroleum Administration for War, and when this organization was dissolved at war's end he became a member of the National Petroleum Council.

He was a director of the A.P.I. for years, was active in civic affairs, and was widely known in educational circles. He was vice-chairman of the Rice Institute Board of Trustees, a member of the Corporation of Massachusetts Institute of Technology, and a charter trustee of Princeton University.

The Rand Medal is presented by a foundation which was formed in 1930 as a memorial to Charles F. Rand. Its primary purpose is to promote the general welfare of the Institute by recognizing distinguished achievement in mining administration. It has been awarded four times, and is one of the four major medal presentations of the AIME. Previous recipients of the medal were: Robert Crooks Stanley, chairman of the board of International Nickel Co.; Cornelius Francis Kelley, chairman of the board of Anaconda Copper Mining Co.; George Magoffin Humphrey, president of the M. A. Hanna Co.; and Eugene Gifford Grace, chairman of the board of Bethlehem Steel Corporation. ★ ★ ★

Millikan, C. V. ..... Ch 30 EC 33-36-40 Nom 38
Morris, W. S. CLS 40 PP 40-41 EC 43-44-45 AC 42 Ch 44 Nom 45
Moore, T. V. ..... ER 35 PE 37 AC 39 Ch 40 EC 41
Moulton, Gail F. ..... Prod 45-46 VC 49
Murrell, John H. ..... CLS 46 VC 47 EC 47-48-49-50
Naramore, Chester ..... EC 44-45
Nowels, K. B. ..... ER 33
Nye, George L. ..... CLS 48
Ogden, L. A. ..... CLS 35
Parks, Ernest K. ..... CLS 45
Parks, Mercer H. ..... CLS 46
Parsons, B. E. ..... EC 34
Pishny, Charles ..... CLS 45
Pollard, Terry A. ..... Me 48 ER 49
Pogue, J. E. ..... Ec 27 Ec 32
Porter, L. E. ..... PE 43
Porter, W. W. II ..... CLS 47 EC 47-48
Posgate, James ..... CLS 48
Power, H. H. PE 34 EC 35-36-40 Ch 35 Me 37 Nom 41 Ed 43-44
Pyle, H. C. ..... Ch 47 EC 47-48 Nom 48

R-Z

Reistle, C. E., Jr. ..... EC 42 AC 43
Rhea, A. A. ..... CLS 42
Sheldon, Dean H ..... CLS 48 EC 49-50-51
Shepherd, Jack M. ..... CLS 49
Sherborne, John E. ER 46 EC 47-48-49 SC 46-47 VC 49 PT 49
Sinsheimer, Warren A. ..... EC 30-34
Somers, R. E. ..... EC 37
Spoor, H. C., Jr. ..... SC 49
Stephenson, Eugene A. PE 32 ST 33-37 inc., EC 34-39-40-41-42-43 PP 38 Ch 41
Stolz, Harry P. ..... AC 41 Ch 42 EC 43 Pro 45
Struth, H. J. ..... EC 32-47
Suman, John R. ..... EC 32-33-34
Swensrud, Sidney A. ..... Ec 35-36-37-38
Teague, J. U. ..... CLS 41
Terry, L. F. ..... EC 39-40-41
Thornton, Owen ..... CLS 49
Trostel, E. G. ..... ER 43 PE 45 CLS 45
Turnbull, Paul ..... CLS 47
Umpleby, J. B. ..... PE 27 Ch 29 EC 32-47 SC 46
Uren, Lester C. ..... Ed 48
Vance, Harold ..... PP 39 EC 41-42 ST 43-44
Vietti, Wm. V. ..... CLS 37 EC 47-48
Van Wingen, Nico ..... PT 47
Walker, A. W. ..... CLS 39 PE 41
Waddill, Alfred W. ..... ME 46
Warner, C. A. CLS 38 Me 39-41 AC 42 Ch 43 EC 44 Pro 46
Wasson, H. J. ..... EC 35 Prod 32 EC 35
Watson, C. P. ..... AC 43 Prod 30
Weaver, P. ..... EC 39 Me 42 Ge 45-46
Wilcox, Stanley W. ..... CLS 44
Wilde, H. D., Jr. ..... PE 33 EC 33-34-35 Ch 34
Wilhelm, V. H. ..... AC 34 RVC 44
Wrather, W. E. ..... EC 33-34 Ch 33
Young, C. M. ..... EE 32-33
Zavoico, Basil ..... Prod 42 AC 43 RVC 43

HERE'S THE LINE ON '49

Fall Meetings in San Antonio and Los Angeles

Preliminary plans for these meetings indicate there will be no slackening in progress toward largest and best meetings possible. The *Journal* will carry month-to-month reports of developments.

SAN ANTONIO

This meeting, originally scheduled for Corpus Christi, will be held on Wed., Thurs., Fri., Oct. 5-6-7. The Plaza Hotel will be the headquarters, with the Gunter and St. Anthony also accommodating our visitors. Harold Decker, vice-president of the Pan American Companies, Houston, has been appointed General Chairman for the meeting, and as such will represent the Branch Executive Committee in matters of policy and coordination.

The Southwest Texas Local Section, Raoul Bethancourt, Sun Oil Co., Corpus Christi, chairman, will serve as host at the meeting. Committee chairmen appointed are: *Finance*, C. H. Snelson, Seaboard Oil Co., Corpus Christi; *Entertainment*, Harry Vaughan, Lane-Wells Co., Corpus Christi; *Hospitality*, Thomas S. West, Buchanan & Blanco Oil Co., San Antonio; *Arrangements*, Weldon W. Hammond, Fair-Woodward, San Antonio; *Hotel*, R. K. Guthrie, Seeligson Engineering Committee, San Antonio; *Registration*, William H. Spice, Jr., consulting engineer, San Antonio.

Hotel Reservations: Reservations should be made early. Your requests should go directly to the hotel of your choice.

The Technical Program: The Production Technology Committee, under John Sherborne, Union Oil Co. of Calif., Los Angeles, chairman, and Morris Muskat, Gulf Research and Dev. Co., Pittsburgh; Paul Turnbull, Humble Oil & Ref'g Co., Corpus Christi, and Lincoln Elkins, Sohio Petroleum Co., Oklahoma City, all vice-chairmen, will arrange the technical program. Several papers of apparent high caliber have been offered and a quantity of others are expected when the newly formed committee begins its solicitation process. The quantity of acceptable material permitting, the program will be arranged on the simultaneous-session plan which proved popular at the 1948 Dallas meeting. No special topical or thematic arrangement has yet been decided upon, but it is probable that at least one major phase of the technology will receive an especially intensive exposition. Refinements in mechanical arrangement which have increased audience comfort and attentiveness in recent meetings will be applied, and if possible, extended.

Exhibit Booths: About 25 exhibit booths will be offered to service and equipment companies for a showing of their latest products and processes. Invitations will soon be issued to prospective exhibitors, with the terms and conditions being similar to those of the past.

Social Activities: Tentative plans call for the use of La Villita, a miniature Mexican village which expresses the real atmosphere of the Mission City, for the annual cocktail party, banquet and dance. No stag events are contemplated. The ladies are warmly invited and will be the guests of honor at one or more special events.

LOS ANGELES

This meeting will be held at the Elk's Club, 607 So. Park View St., on Thursday and Friday, Oct. 20-22. This club offers hotel accommodations to those from outside Los Angeles. The Pacific Petroleum Chapter, under the chairmanship of Paul Andrews, Signal Oil & Gas Co., will serve as host for the meeting. It is hoped that current plans for the activation of a Pacific Chapter organized group in the San Joaquin Valley will have matured long before meeting time and that the participation of this group will be greater than ever.

John H. Thacher, Southern Division Manager, Standard Oil Co. of Calif., will serve as General Chairman for the meeting. Committee chairmen appointed are: *Arrangements*, H. J. Stroud, Signal Oil & Gas Co.; *Exhibits*, Ray Hancock, Lane-Wells Co.; *Publicity*, Frank S. Parker, Signal Oil & Gas Co.; *Luncheon*, Basil P. Kantzer, Union Oil Co. of Calif.; *Program*, John E. Sherborne.

The Technical Program: The Branch Production Technology Committee is also a source of papers for this meeting and works in conjunction with the Program Committee in assembling the technical program.

Exhibit Booths: About 25 exhibit booths will be offered to service and equipment companies for a showing of their latest products and processes. Invitations will soon be offered to prospective exhibitors, with the terms and conditions being similar to those of the past.

Social Activities: A luncheon and business meeting of the Pacific Petroleum Chapter will be held at the Town House, with the traditional Southern California Section banquet being held on the second night of the meeting.

Branch Membership Continues Growth

A new record for success was registered during 1948 by the Petroleum Branch membership committee, headed by Terry A. Pollard. Of the 1735 new members accepted by the Institute, 504, or 29 per cent were accredited to the Branch. This record prolongs the trend of the past several years, as shown by the tabulation:

Year	New Members Accredited to Petroleum Branch	Per Cent of Total New AIME Members
1943	241	18.5
1944	279	19.5
1945	274	21.1
1946	462	27.0
1947	458	30.9
1948	504	29.0

Significant to this accomplishment was the increase-in-membership activity in the Gulf Coast and Mid-Continent Local Sections. These Sections led all others by each securing 73 new petroleum members during the year. A tabulation of results by Local Sections shows:

Section	New Members Accredited to Section
Gulf Coast	73
Mid-Continent	73
North Texas	61
Pacific Petroleum Chapter	51
Delta	38
Southwest Texas	35
East Texas	31
Oklahoma City	27
Permian Basin	26
Kansas	23
Total from Sections	438
Total from unsectionalized areas	66
Total for Petroleum Branch	504

Membership Chairmen for the Gulf Coast and Mid-Continent Sections were, respectively, Herman Otto, J. S. Abercrombie Co., and John Arps, British American Oil Prod. Co. The record of the Kansas Section is imposing as it was compiled in the first two months of the Section's existence. V. J. Mercier, the Section Chairman, was principally responsible.

Total Petroleum Branch membership as of January 1, 1949, is estimated at 4,050, as against 3,600 a year ago. An estimate is necessary because the regrouping of the AIME membership into three principal Branches — a process based on receipt of dues payments and publications selections — is not yet complete. If the rate of net increase in Branch strength established from 1946 through 1948 is approached in 1949 and 1950, the non-student membership at the end of the latter year will be over 5,200. Petroleum Student Associate membership has been increasing rapidly since the war and is now estimated at 800, these being in addition to membership totals mentioned above.

The Membership Committee for 1949 will be under the direction of Frank Briggs, Houston Oil Field Materials Co., Houston. The *Journal* will be utilized in membership promotional efforts. A short term free subscription to eligible non-members is under advisement. ★ ★ ★

Gas Short Course Slated

The Fourth Annual Short Course in Gas Technology will be held at Texas College of Arts and Industries in Kingsville from May 30 through June 1. This program of lectures and assemblies is sponsored by the Southern Gas Association.

Frank H. Dotterweich, director of the A & I engineering division, is chairman of the administrative committee. Working with him to plan the course are Chester Young of Lone Star Gas Co., Dallas, chairman of the utilization section; D. T. MacRoberts, of United Gas Pipe Line Co. of Shreveport, chairman of the production and transmission section; W. B. Wood of Rio Grande Gas Co., Brownsville; C. A. McKinney of United Gas Corp., Houston; W. C. McGee, Jr., of Tennessee Gas Transmission Co., George Elmer, of New Orleans Public Service; R. M. Hutchinson of Houston Natural Gas Corp.; W. H. Ligon of Nashville, president of the Southern Gas Association; and R. R. Suttle, Dallas, managing director of the association.

Symposium Scheduled In Houston

The Engineers Council of Houston has scheduled its second annual symposium for April 2, 1949, in the Rice Hotel. The subject will be "The Conservation of Our Natural Resources", and five papers on the major phases of conservation will be presented by nationally prominent authorities.

Installment Plan for AIME Transactions

It has been pointed out to us that payment of $36.00 all at one time for a set of the reprinted Petroleum Transactions — 1936 through 1946 — works a hardship on many of the younger members who would like to have the books. In order to make it as convenient as possible for all who would like to have the books, the Branch Chairman has authorized an installment purchase plan. All members (including Student Associates) who desire to do so may purchase the set or any part of it at $6.50 with the order and $6.50 per month thereafter until paid for, providing only that the member notifies the Dallas office, at the time he places the order, that it his intention to take advantage of the easy payment plan.

Delta Section Activities

By J. Paul Ratliff, Jr.

The first meeting of 1949 was held at the New Orleans Petroleum Club on January 11. E. N. Dunlap, new section chairman, turned the meeting over to E. N. VanDuzee immediately after dinner for a lively discussion on the ensuing year's program. This discussion resulted in approval of plans for a student paper program and a dinner-dance during 1949.

Left, Thomas Doyle, who discussed cycling in an Erath reservoir, and right, Leo Hines, who presented a discussion of the Hock paper at the January 11 meeting.

Ralph Hock, chief engineer of the Cotton Valley Operator's Committee, was the principal speaker for the evening, and the cordial reception granted him by the 58 members and visitors in attendance indicated the popularity of his subject, *Determination of Cycling Efficiency in the Cotton Valley Field Gas-Condensate Reservoirs*. Because of the increasing importance of gas-condensate production throughout the Delta Section area, listeners were impressed with Hock's development of fundamental equations for determining displacement efficiency, pattern efficiency, pattern efficiency, and cycling efficiency from actual field data. Also, it was interesting to learn that the results of potentiometric model studies at Cotton Valley checked very closely with actual field determinations of cycling efficiency.

In a prepared discussion, Leo E. Hines, chief cycling engineer with the California Company at Natchez, presented an excellent critique on the various efficiency equations used by Hock. Using actual data curves, Hines showed that varations in the interstitial water content of different parts of a reservoir must be considered in determining cycle efficiency. Thomas W. Doyle, chief engineer for the Texas Company at Erath, presented a very interesting discussion on the mechanics of cycling in a representative Erath reservoir. In a subsequent general discussion, J. M. Dillon, Shell Oil Company, and Guy Borden, Jr., Louisiana State University, deplored the fact that insufficient data are available in most instances to permit the use of potentiometric and electrolytic model studies. ★ ★ ★

Officers and directors of the Delta Section for 1949, chosen at the section meeting on December 21, 1949.

Row 1, left to right: A. Claudet, Schlumberger Corporation, section director; E. G. Robinson, Shell Oil Company, section director; and E. N. VanDuzee, Shell Oil Co., chairman activities committee.

Row 2, left to right: E. N. Dunlap, California Research Corporation, section chairman; D. D. Utterback, Houston Oil Co. of Texas, program committee; Charles R. Blomberg, The California Company, vice chairman; H. C. Peterson, Freeport Sulphur Company, section director; H. M. Krause, Jr., Humble Oil & Refining Company, vice chairman; and Fred E. Simmons, Jr., The Louisiana Land & Exploration Co., secretary-treasurer.

Other directors named, who are not shown above are: B. C. Craft, Petroleum Engineering Dept. of L. S. U., and J. C. Posgate, Humble Oil & Refining Company.

Oklahoma City Section Activities

By Harold Sells

The regular monthly meeting of the section, which was well attended by members and guests, was held January 18 at the Biltmore Hotel in Oklahoma City. Primary business of the meeting was election of officers for 1949, which resulted in the following being selected: Lincoln F. Elkins, Sohio Petroleum Company, chairman; N. vanWingen, University of Oklahoma faculty, vice-chairman; Henry Waszokowski, Magnolia Petroleum Company, vice-chairman; and Martin Hegglund, Stanolind Oil & Gas Co., secretary-treasurer.

Directors chosen for the ensuing year were: Charles E. Clason, Halliburton Oil Well Cementing Co.; R. J. Beams, consultant, and H. R. Sells, Sohio Petroleum Co.

Members and guests attending were keenly interested in a presentation by R. A. McLemore of Welex Jet Services, Fort Worth, who was featured speaker of the meeting. McLemore presented his paper entitled, "*The Jet Process of Perforating Oil Well Casing*,"* using verbal discussion and slides.

* This paper was also presented at the East Texas Section Meeting a week prior to the Oklahoma City meeting, and for this reason it is reviewed along with the East Texas Section news in this issue — THE EDITOR.

N. van Wingen, 1949 vice-chairman. California Institute of Technology in engineering, University of California, M.Sc. in petroleum engineering. Formerly with Continental and Richfield; now professor of P. E. in University of Oklahoma.

General News

The reservoir engineering study group of the section has resumed operations. Work on the project initiated last year has been continued, and plans made for additional projects this year. The project continued from last year is a geological and reservoir analysis of the Southwest Antioch Field, Garvin County, Oklahoma. All members are invited to participate in this engineering study group, which is directed by J. C. Calhoun, Jr.

A directory of members of the local section is being prepared and will be issued to all members within the near future.

Henry Waszkowski, 1949 vice-chairman. Louisiana State U. in petroleum engineering in 1939. With Magnolia since, except while in the Navy, and is now Oklahoma Division Engineer.

A donation of scientific equipment to the University of Oklahoma has been announced by Stanolind Oil & Gas Co. The equipment will aid research work being done in the Petroleum Engineering Department pertaining to studies in relative permeability. Core samples taken from various oil producing formations are injected in one end with oil, gas and water, and the new apparatus tests their progress through the core. Predictions of probable reservoir performance are then based on the results.

Two graduate students at the university are now doing research on the subject. Relative permeability tests show the increased force necessary to move oil through a rock when gas and water are also present in the formation, over what is required when oil alone is present.

Lincoln Elkins, 1949 chairman, Colorado School of Mines in petroleum engineering in 1940, graduate work in University of Texas. Previously research engineer with Stanolind, production engineer with Continental, and now special projects engineer with Sohio.

Oklahoma City Personals

J. C. Calhoun, Chairman of the Petroleum Engineering School, University of Oklahoma, will present a paper detailing capillary pressure theory and application at the coming AIME convention in San Francisco. **N. van Wingen,** Professor of Petroleum Engineering at Univ. of Oklahoma, will also attend the San Francisco convention. **Lincoln F. Elkins,** Sohio Petroleum Company, will attend the convention as a delegation from the Oklahoma Section of AIME.

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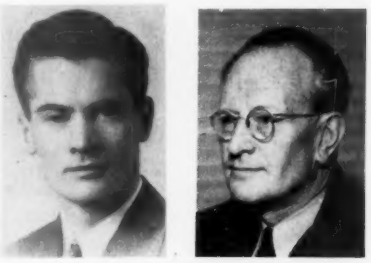

Martin Hegglund, left, Sec.-Treas. for 1949; graduate of Colorado Mines; service with Stanolind; now project engineer in division office. Charles Clason, right, Michigan, 22 years with Dow and Dowell; now with HOWCO as advisor on acidizing.

Mississippi Sub Section Activities

The AIME and petroleum engineering took a step forward in late 1947 with the organization of the Mississippi Subsection of the Delta Section. Starting from a small group, the membership, as well as interest in Section activities, has increased rapidly during recent months. Covering the southern half of Mississippi, its meets every other month, alternating between the cities of Jackson, Laurel and Natchez.

An example of this program was the January 28 meeting of the section, when about fifty members and visitors attended an all-day field trip and evening program.

Subject and locale of the field trip was the Waterways Experiment Station of the Mississippi River Commission, located at Vicksburg and Clinton, Mississippi. This station, which is operated by the Corps of Engineers of the Army, exists for the purpose of studying water and flood control, with special attention given to the Mississippi River Basin. It is divided into four primary divisions of Hydraulics, Soils, Concrete and a Research Center.

Two principal government reservations comprise the station. The Vicksburg installation consists of about 500 acres in land area and houses the main administrative headquarters, the Hydraulics, Soils and Research Divisions, and employs 900 people. About 820 addition acres 40 miles east of Vicksburg near Clinton, constitute the Concrete Division, which employs 350 people.

The morning of January 28 was devoted to a tour of the Concrete Division at Clinton, which was conducted by two AIME members, Bryant Mather and Cecil H. Willetts. This division has been assigned the mission of conducting all major research activities required by the Corps of Engineers pertaining to the basic improvement of concrete.

Located in the Concrete Division area is a 200-acre model of the Mississippi River Basin, which is used to study flood control in the entire drainage basin of the river and its tributaries. This is the largest hydraulic model in the world, and reproduces the entire 1,250,000 square miles of the river basin, which is 41 per cent of the United States. Costing $6,000,000, the model is so designed that it can be operated as a complete unit or in part for study of local problems.

After moving to Vicksburg, the AIME group spent the afternoon visiting the Hydraulics and Soils Divisions. Established originally in 1929 to study the lower Mississippi basin, the work of the division has been expanded to other waterways, and over 300 studies have been conducted since its establishment. Among its problems are flood control and navigation, hydraulic structures such as spillways, and special studies of such water problems as tides, wave action and river meander.

The Soils Division was established in 1932 primarily to design the extensive system of levees in the lower Mississippi valley. It is divided into two branches, Embankment and Foundation, and Flexible Pavement. The first is primarily concerned with the civil works program of the Corps of Engineers, and that of the Mississippi in particular. The second deals primarily with military problems such as airfield landing strips.

Fifty-two members and visitors returned to Jackson in the evening for a dinner meeting at LeFleurs Restaurant. Primary business for the meeting was the election and installation of officers. Nominees had previously been submitted to the membership, and votes were cast by prepared paper ballots. No other nominations were offered and the following officers were elected for 1949: R. E. France, California Co., Natchez, chairman; Harold Leeton, Gulf Refining Co., Laurel, 1st vice-chairman; J. G. Walvoord, Humble Oil & Refining Co., Columbia, 2nd vice-chairman; and A. W. Gunther, California Co., Natchez, secretary-treasurer. Directors elected were: Dave Harrell, Sun Oil Co., Jackson, J. K. Wright, Miss. Oil & Gas Engr. Committee, Jackson, T. B. Young, Gulf Oil Co., Laurel, Jack Petrofsky, Laurel, and Weldon Ramseur, past chairman.

Principal speaker of the evening was H. E. Dewey, chief of the Mississippi Basin Branch of the Waterways Experiment Station. He reviewed the station's history, which really started in 1879 when Congress authorized the Mississippi River Commission. After the flood of 1927, Congress directed that a hydraulics laboratory be established. Since then the scope of the station's work has expanded, and it has received many calls to conduct research problems. Dewey continued an informative period with slides showing the organization of the entire Waterways Experiment Station, which provided a well-rounded ending to the day's field trip and meeting. ★ ★ ★

Officers for 1949, Mississippi Sub Section of the Delta Section
FRONT, L. to R.: J. G. Walvoord, Humble Oil & Refining Co., Columbia, Miss., 2nd vice-chairman; Harold Leeton, Gulf Refining Co., Laurel, Miss., 1st vice-chairman; W. W. Ramseur, Gulf Refining Co., retiring 1948 chairman.
BACK, L. to R.: J. K. Wright, Jr., Miss. Oil & Gas Engr. Committee, Jackson, director; Jack Petrofsky, Frank and George Frankel, Laurel, Miss., director; and Tom Young, Gulf Refining Co., Laurel, Miss., director.
1949 officers who are absent are R. E. France, chairman, A. W. Gunther, secretary-treasurer, and Dave Harrell, director.

Gulf Coast Section Activities

By J. E. Kastrop

The answer to the much-asked question, "Who's going to be the new chairman?" was supplied by unanimous vote of 120 Gulf Coast members at the January 18 meeting in Houston when Owen Thornton was awarded the honor. A reservoir engineer with The Texas Company in Houston, Thornton was chairman of the energetic program committee which provided the 1948 Gulf Coast meetings with outstanding speakers and programs.

E. B. Miller, Tide Water Associated Oil Company, Houston, was elected vice chairman. Continuing with the practice of electing one representative from each of the two petroleum engineering schols in Texas, the group named George Fancher of University of Texas and A. B. Stevens of Texas A & M as vice chairman. Both are professors of petroleum engineering. Everett Stratton, Schlumberger, Houston, was elected secretary-treasurer.

Three new directors elected were Fred Nelson, Texas Gulf Sulphur Company, G. D. Robertson, Shell Oil Company, and L. B. Uhrig, Humble Oil & Refining Co., all of Houston.

Committee chairmen for 1948 reviewed their activities during the past year. Interesting among these were the attendance and membership reports. Average attendance during the year was 125 as compared to averages of 108 for 1947 and 102 for 1946. Total membership of the section is now 530, 470 of which are national members and 60 are Gulf Coast Associates. Herman Otto, chairman of the membership committee, reported that 130 new members had been added and 160 had been lost during the past year.

Mercer Parks, AIME representative on the Houston Engineers Council, stated that a one day symposium is scheduled before this group for 1949. It will feature five outstanding speakers who will discuss the conservation of: (1) water, (2) fuel and power, (3) soil, (4) character of man, and (5) man himself.

Featured speaker of the meeting was Paul Weaver, chief geophysicist of the Gulf Oil Corporation, who presented an outstanding discussion entitled "Water Supply Problems for Mining and Oil in Texas." A member of a legislative committee studying the uses of water in the state, Weaver stated that Texas is on the threshold of some important decisions about the state's water supply. He described the present shortage of water in the state and how it affects the oil industry. According to existing state laws, priority water in petroleum production is far down on the list.

George L. Nye, outgoing chairman of the Gulf Coast Section, congratulates Owen Thornton upon being elected as the 1949 chairman.

Water used for injection wells in secondary recovery projects is not returned to the surface, and is considered consumptive water.

Weaver said that the relationship of use and supply of water must be established from a complete inventory of current water needs and sources of supply. It is to the interest of the oil industry to see that those who are appropriated water use it, and if they do not require it, to let others on the priority list have it. He said that water exists below the zone of fresh water that can supply large quantities now drawn from fresh water sources. Other mineralized waters below the fresh water level (such as in the middle Wilcox) could supply large volumes neded for mining and petroleum. ★ ★ ★

Old and new officers of the Gulf Coast Section. Left to right in front row are: A. S. Parks, 1948 vice chairman; E. B. Miller, 1949 vice chairman; L. B. Uhrig, newly-elected director; Everett Stratton, 1949 secretary-treasurer, and A. W. Waddill, director. Back row, left to right: G. R. Sparenburg, director; Ralph W. Wilson, director; Fred Nelson, 1948 secretary treasurer and newly-elected director; and Harold Decker, 1947 chairman and director.

Kansas Section Activities

By Carl Lund

Much progress has been made by the Kansas Section since its organization on December 17, 1948. A strong interest has been manifested in Section activities from many people, and the membership position has improved. The section now has seven new members confirmed, 28 applications pending, and 36 affiliate members. Enthusiasm continues to grow rapidly, and prospects for the organization are very bright.

The regular monthly meeting was held January 7 at the country club in Eureka, Kansas. Gene Abernathy and Paul Witherspoon are due much credit for their efforts in promoting the meeting, as there were 30 members present, six student associates, and 40 visitors. Gene Witherspoon incidentally exposed his ability as a raconteur by telling a yarn that might be of questionable propriety in some circles, and made himself liable for future calls.

Kansas Section Vice-Chairman Dan Sholtus, Great Lakes Carbon Corporation, makes a strange gesture as if he were pouring some "ingredient" into the party bowl at the December meeting in Wichita. Eager beaver Ken Smith, Stanolind Oil & Gas Co., samples the mixture as it coagulates.

Chairman V. J. Mercier conducted the business meeting. Of primary interest was a resolution on awards for technical papers which had met difficulty in discussion in the December meeting, and was carried over. The resolution was to sponsor cash awards for outstanding technical papers written by members of the section, and also to sponsor a cash award for the best student associate paper submitted during each school year. The papers submitted in each case are to be reviewed and judged by a committee on awards, and the award is to consist of a suitably engraved certificate and a cash prize, the amount of which will depend on the funds available.

The resolution was adopted as read, and Chairman Mercier appointed the awards committee. Those appointed are: E. A. Stephenson, head of the Petroleum Engineering Department, University of Kansas, chairman; John R. Berg, Professor of Geology, University of Wichita, and George L. Yates, Amstutz and Yates, Inc., Wichita, Kansas.

William E. Stiles of Core Laboratories in Dallas delivered the talk for the evening with his paper *Use of Permeability Distribution in Water Flood Calculations*. This presentation was particularly opportune and appropriate, as the area around Eureka is now confronted with many water flooding problems. The Stiles paper was presented in full in the January *Journal*.

A lively discussion period followed the meeting, which indicated the keen interest of the membership in the subject. Ward McGinnis, independent operator of Eureka, Kansas, suggested that the section make a field trip through Eastern Kansas water flood properties in the late spring. The response to this was so enthusiastic that Gene Abernathy and Paul Witherspoon were asked to make a study of the possibility of such a trip.

Potentials

V. J. Mercier of Lane-Wells Company spoke to the petroleum engineering and geology students of the University of Wichita on the subject of radioactivity and well logging on January 12. After his talk, he put in a plug for the Kansas Section by explaining the benefits of affiliation with AIME, and urged the group to start a student association.

Kansas Personals

Uncle Sam will have to refigure his budget for '49, because **Mike Mercier** became the father of a six-pound baby boy on January 1, giving him a total of four exemptions.

The following newcomers have arrived in the Jayhawker state; **R. A. Auckerman,** district engineer, Shell Oil Co., McPherson, Kansas; **William R. Goodier,** field engineer, Shell Oil Co., Great Bend, Kansas; and **Raymond Gahan,** district engineer, Anderson-Prichard Oil Corp., Great Bend, Kansas.

★ ★ ★

Two groups discuss petroleum engineering and the new Kansas Section of AIME at the organizational meet in December. They are, left to right: Martin E. True of Houston, who presented a paper for that meeting; A. Owen Holliday, Wichita, Kansas; C. F. Weinaug and Ellis Anders, University of Kansas.
RIGHT PICTURE: F. C. Austin, Wichita, Bill Nation, Wichita, Marion Miller, Wichita, Joe Beggs, McPherson, and Monty Smith, Wichita, Kansas.

Mid-Continent Section Activities

By H. A. Koch

Monthly Meeting

G. C. MacDonald, Gulf Oil Corp., was the principal speaker at the regular monthly meeting January 10, with a talk on "Transportation of Bit Cuttings in a Rotary Drilled Well". The speaker mentioned some of the problems encountered in the actual transportation of the bit cuttings from the well. Although this might seem to be a relatively simple subject, it was pointed out that there are still a large number of problems dealing with this phase of drilling for which solutions have not as yet been found. MacDonald also pointed out the desirability of taking into consideration the annular flow velocity of the mud coming from the hole rather than relying on pump pressures alone, which is common drilling practice today. The speaker has done considerable research in this connection, and, during the course of his talk, displayed a number of charts he had developed which are very useful in determining annular flow velocities under practically every condition.

G. C. McDonald, Gulf Oil Corp., who spoke at the January 10 meeting on "Transportation of Bit Cuttings in a Rotary Drilled Well".

Since his graduation in 1928 from the Colorado School of Mines, with a degree in Petroleum Engineering, MacDonld has had considerable experience in the drilling and production fields. His activities have taken him to Venezuela and Mexico. Just recently he was responsible for the completion of a well along the northeast coast of Nicaragua.

Study Groups

The Production and Drilling Study Group Meeting was held on January 18. W. F. Freeman, Ajax Iron Works, led a discussion on "Performance and Operation of Oil Field Engines".

The Reservoir Study Group Meeting for the month was postponed due to bad weather. It will be re-scheduled at a later date, and will be conducted by Z. Z. Hunter, Phillips Petroleum Co., on "The South Burbank Unit".

Resignation of First Vice-Chairman

J. M. Walker, Lane-Wells Co., resigned as First Vice-Chairman of the section, due to his transfer to California. Walker has been very active in both the AIME and other organizations in Tulsa, and will be missed by his many friends in this area. At a meeting of the Executive Committee, H. M. Cooley, Bethlehem Steel Co., was unanimously elected to fill this vacancy.

San Francisco Meeting

The Mid-Continent Section will be represented at the AIME National Meeting in San Francisco by AIME Director C. V. Millikan and Section Chairman J. P. Hammond of Amerada Petroleum Corp.; Petroleum Branch Chairman-elect L. E. Elkins, Stanolind Oil & Gas Co.; Section Chairman-nominee H. M. Cooley, Bethlehem Steel Co.; Petroleum Branch Vice-Chairman P. E. Fitzgerald, and Delegate M. L. Stirling, both of Dowell Incorporated.

Report of Nominating Committee

A Nominating Committee composed of P. P. Manion and L. E. Elkins, both of Stanolind Oil & Gas Co., and R. C. Earlougher, Earlougher Engineering Co., announced the selection of candidates for offices in the Mid-Continent Section for 1949-50. They are as follows:

Chairman—H. M. Cooley, Bethlehem Steel Co.

First Vice-Chairman—A. W. Francis, National Tank Co.; R. H. Smith, Stanolind Oil & Gas Co.

Second Vice-Chairman—J. N. McGirl, Tide Water Associated Oil Co.; C. C. Rodd, Gulf Oil Corp.

Secretary-Treasurer—J. H. Beesley, Baroid Sales Div.; H. A. Koch, Dowell Incorporated.

Executive Committee—W. L. Horner, Barnsdall Oil Co.; H. L. Crisman, W. C. McBride, Inc.; W. H. Burke, Shell Oil Co.; C. O. Moss, Deep Rock Oil Corp.; C. M. McIntosh, Earlougher Engineering Co.; G. M. Stearns, Stanolind Oil & Gas Co.; D. R. McKeithan, Phillips Petroleum Co., Bartlesville; J. A. Murphy, Continental Oil Co., Ponca City, and A. B. Cook, Bureau of Mines, Bartlesville.

These nominations are to be presented at the February meeting, at

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Wm. E. Schoeneck, recently appointed vice-president of British-American Oil Producing Company, with offices in Tulsa. He will direct production and engineering for the Mid-Continent Division of the company. A native of Pittsburgh, he graduated from the Univ. of Pittsburgh, and has since had wide experience in petroleum engineering and production.

Retiring Vice-Chairman J. M. Walker (right) of Lane-Wells Co., and 1949 Chairman-nominee H. M. Cooley (left) of Bethlehem Steel Co., discuss prospects for the Mid-Continent Section during 1949.

East Texas Section Activities

By Roy F. Beery

ROY F. BERRY, a native of Oatman, Arizona, and a B.S. in P.E. graduate of Univ. of Texas, who is *Journal* Secretary for the East Texas Section. Service with Texas Co., and Shell and U. S. Navy. Received Silver Star for directing naval gunfire during Normandy invasion. Now Kilgore district engineer for Shell.

The Gregg County Airport, one of the Southwest's most modern airfields, which is midway between Longview and Kilgore, was the site of the East Texas Section meeting on January 11. Although the weather resembled one of Paul Bunyan's "blue northers", the dinner and speaker attracted a crowd of 75 members and visitors, which was the largest meeting attendance in months.

Chairman Jack Shepherd reported that the officers and board of directors met January 6, for the purpose of appointing 1949 committees, and introduced those selected. Roland K. Thies is chairman of the program committee, and other members are F. L. Thompson, C. O. Hopper, Jr., A. H. Crawford, H. K. McArthur and Ollie J. Ford. The membership and attendance committee is headed by T. L. Forehand with a membership of Ed Stanley, P. E. DesJardins, P. G. Burnett, D. Moore, R. J. Williams, and L. H. Meltzer. Riley Aucoin and Don Keer comprise the audit committee.

Directors of the East Texas Section: left, W. M. Jones, Stanolind Oil & Gas Co., Greggton; right, R. M. Hess, Shell Oil Co., Kilgore.

R. H. McLemore of Welex Jet Services, Inc., in Fort Worth, held the close attention of those attending with an excellent discussion, "The Jet Process of Perforating Oil Well Casing." The paper traced the development of "jet" or "shaped charge" perforating from 1880 to the present, and described the theory and application of this perforating method. By a series of slides, McLemore reviewed the factors affecting diameter and depth of perforation, such as variations in the shape, diameter or thickness of the cone. The hole made in the cement and formation starts with 5/8" or 3/4" diameter and tapers to 1/4" or 1/6". Thousands of minute metal particles traveling at 30,000 feet per second perform the cutting and abrasive action which causes penetration, rather than a burning action causing it.

W. W. Leonard, Continental Supply Co., Shreveport, vice-chairman of the East Texas Section for 1949.

The effect of the jet on permeability in the formation was discussed and the fact brought out that the temperature involved has no detrimental effect on the permeability of the producing zone. The depth of penetration through various casing strings and various sizes of charges was given. Slides were shown of an experiment performed using a 21 gram charge which penetrated a 1/4" steel plate, 1" of cement and 6 or more inches of limestone.

Problems which are peculiar to the selective firing of jet perforating were mentioned, and the reasons were given why selective firing is not at the present time practical from an economic standpoint. Effects of the jet on the well casing were also discussed and test results cited which clearly indicate that no damage is suffered by the casing due to the simultaneous firing of the 24 to 48 shots. The sizes of the charge carriers or guns which are currently available were given, together with the proper size powder charge for each carrier and the recommended size carrier to be used in the various casing sizes in order to secure the maximum penetration.

It was announced that the next meeting, scheduled for February 8, will feature a talk by Jack C. Webber on "Fundamental Hydraulics Involved in the Use of Oil Well Packers." ★ ★ ★

J. M. Shepherd, Humble Oil & Refining Co., Tyler, chairman of the East Texas Section for 1949.

North Texas Section Activities

By Kenneth F. Anderson

About 60 members and guests gathered at the Melrose Hotel in Dallas on January 5 to participate in the election of officers to serve during 1949, and to hear a talk entitled "Oil and Gas Conservation" by Wallace Hawkins, vice-president and chief counsel of Magnolia Petroleum Co.

Nominating Committee Chairman G. E. Woodward, presented the committee's nominations for new officers, and all candidates named were elected by acclamation. Don L. Harlan, division petroleum engineer of The Texas Company in Fort Worth was elected chairman. Vice-chairmen selected were Jack A. Crichton, DeGolyer and McNaughton, Dallas; I. E. Curtis, chairman of operator's committee for Hull Silk Pool, Wichita Falls, and J. A. Slicker, Stanolind Oil and Gas Co., Fort Worth. S. V. McCollum, Continental Oil Co., Fort Worth, was elected secretary-treasurer.

Directors named for 1949 were: retiring chairman Warren J. Jackson, Lane Wells Co., Dallas; D. H. Clewell, Magnolia Petroleum Co., Dallas; Tom E. Morton, Halliburton Oil Well Cementing Co., Wichita Falls; E. E. Merkt, Jr., Gulf Oil Corp., Ft. Worth; W. D. Sorrells, Bennett and Sorrells, Wichita Falls; and L. P. Whorton, Atlantic Refining Co., Dallas.

Vice-Chairman Jack Crichton introduced the speaker, Wallace Hawkins, whose talk dealt with the legal history of oil and gas conservation, and is summarized below:

After 25 years of trial and error, the oil and gas producer has discovered and established rules and principles for the development and operation of petroleum reservoirs in order to prevent waste, protect correlative rights, and protect the public interest. These rules and principles have been enacted into statutory law, largely by states. Development of our conservation system has been retarded by our heritage of constitutional property rights, and the late arrival of the scientist on the oil producing scene.

Despite the many problems involved, as of this date, conservation measures are being practiced in 35 states, and as a general observation it can be said that conservation as a system of regulation in this country is probably reaching a mature pattern embodied in local state law and supported by the federal hot oil act.

It should not be assumed, however, that oil and gas conservation has matured as a finished and complete system, accepted by all acquainted with it. The controversy about the use of market demand as a factor or technique in the control of production to prevent waste and to protect correlative rights in the public interest still rages. One side claims that this creates state monopolies, and the other claims that it accomplishes conservation. The speaker was of the opinion that a barrel of oil on the well-side of the choke and barrel of oil on the battery-side of the choke produce the same and identical economic consequences, and that each has the same influence upon the price of crude.

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HAWKINS: " . . . *a barrel of oil on the well side of the choke and a barrel of oil on the battery side of the choke produce the same economic consequences . . .* "

New officers of the North Texas Section receiving their gavel for the ensuing year. Left to right are: Don L. Harlan, Fort Worth; Jack A. Crichton, Dallas; I. E. Curtis, Wichita Falls; S. V. McCollum, Fort Worth, and J. A. Slicker, Fort Worth.

Pacific Petroleum Chapter Activities

By Frank Parker

FRANK S. PARKER, *Journal* Secretary for the Pacific Chapter, is a true native son of Los Angeles. Attended the Univ. of Calif. at L. A. (A.B. 1928) and Berkeley and Yale University. Served as geologist and petroleum engineer from 1929 to present with U. S. Geo. Survey, Washington; Shell Oil Co., L. A.; Wilshire Oil Co., L. A.; Pet. Admin. for War, District 5; and Signal Oil & Gas Co., L. A. Joined AIME in 1940, serving sec.-treas. Pacific Chapter, 1948-49.

The Pacific Petroleum Chapter has a good start for the year 1949 under the Chairmanship of Paul Andrews, with work progressing on various projects. The owners of a few willing shoulders carrying the program are F. L. Wadsworth, Field Trip Chairman; Charles Gates, Technology Forum Chairman; and Basil Kantzer, Luncheon Meetings Chairman.

An outstanding feature of the Chapter is the Petroleum Technology Forum in which papers have been presented by specialists on an integrated program of subjects covering all phases of petroleum engineering. This series of monthly meetings, now in its third year, has been an unqualified success under the leadership of Jan Law, Nick Van Wingen, Charles Dodson and the current chairman, Carl Tutschulte. These men have left a high score to shoot at for Charles Gates, who takes over this project in March.

TOP — Carl Tutschulte (left), chairman of the Petroleum Technology Forum, passes a few remarks to Art Brown, speaker for the January 24 meeting. Their expressions date the picture as being taken before the recent crude price cut.
BOTTOM — The Petroleum Technology Forum of the Pacific Petroleum Chapter at the January 24 meeting in Los Angeles.

Attended by some 75 willing-to-learn petroleum engineers, a very informative session of the Forum was held Monday evening, January 24, in the Ethyl Building, Los Angeles. This meeting featured "Reservoir Performance of the Capitan Field", presented by Arthur L. Brown, Exploitation Engineer, Shell Oil Co., Inc., Ventura, California. Brown is a native of New England who thought that oil came out of gas stations until he signed up with Shell after graduation from Brown University in '39 with a B.Sc. Those attending the Forum will agree that he now knows as much about where oil comes from—or at least how it gets out of there—as some who got their pants warmed by Dad for playing around the sumps.

The Capitan Field, discovered in 1929, is located 24 miles west of Santa Barbara on the California coast. So far the Vaqueros (marine Lower Miocene), the Erburu, the Covarrubias (non-marine Oligocene), and the Coldwater (marine Eocene) zones have yielded commercial production. Brown discussed principally the Vaqueros, a water drive pool, and the Erburu, a depletion pool. These pools are unique as, for a month and a half during the war when tankers were diverted to emergency war service, the wells were shut in, thus enforcing an experiment that reservoir engineers have always itched to carry out. The performance of the Vaqueros pool under different rates of production, the effects of shutting in both the entire field and selected wells, of attempting to maintain a level water table by controlled rates of production, and of varying the tubed depth in order to skim oil from above the water were described. The conclusion was stated that in an active water drive field of this type a high rate of production is most successful. Shutting in appears to have resulted in slight, if any, permanent damage to the reservoir, and the oil cannot be skimmed effectively from above the water by tubing the wells high.

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Junior Group Activities
Pacific Petroleum Chapter

By Irving Dagan

November Meeting

A. G. Bodine, of the Bodine Soundrive Equipment Company, gave a most interesting and informative talk on the application of acoustics and sonic principles to petroleum production practices before the November 9, 1948 meeting of the Junior Group of The Pacific Petroleum Chapter. More than seventy members and guests gathered at the Rio Hondo Country Club in Downey, California, to hear Bodine discuss the design and construction of drilling and production equipment for the oil industry utilizing the principles of controlled mechanical vibration to produce high dynamic forces. Data on tests of a sonic pump were presented as well as details of pump design, construction and operation. A lively question and answer period ensued for nearly one hour following Bodine's initial presentation.

December Meeting

One of the largest groups ever to attend a meeting of the Junior Group assembled at the Rio Hondo Country Club on December 9, 1948, to hear Howard G. Vesper, President of the California Research Corporation, speak on "Trends in Research." More than 115 persons crowded the main dining room to get an insight regarding the future of the oil industry as indicated by the present research and development activities of one of the country's major research organizations. Vesper's remarks proved to be most stimulating as the group bombarded him with questions for nearly one hour when the meeting was opened for discussion.

January Meeting

In response to many requests, a "Reservoir Engineering Panel," composed of M. B. Standing of the California Research Corporation, Milan Arthur of the Union Oil Company of California, Oran Graybeal of the Barnsdall Oil Company, Frank Carter of the General Petroleum Corporation and Jan Law, petroleum consultant, discussed reservoir engineering problems referred to it by members and guests who atended the January 13, 1949 meeting of the Junior Group at the Rio Hondo Country Club, Downey, California. R. L. Parsons of the California Research Corporation acted as moderator for the panel.

Indicative of the regard in which the panel members are held and the interest in the subject was the fact that more than 110 braved the wintry blasts of Southern California's "unusual" weather to attend this meeting. A very spirited and stimulating question and answer period ensued for approximately two hours with a very large percentage of those in attendance entering into the general discussion. Questions ranged from "what is a reservoir?" and "what is the deposition, occurrence and nature of clay particles in oil sands?" to "what are the relative merits of the several different methods of performing relative permeability and water saturation measurements?"

The meeting was adjourned only when it was apparent that the panel members had reached an advanced state of physical exhaustion and the group was assured that a similar type of meeting would be held again.

L. W. Chasteen, graduate of U. S. C., and a petroleum engineer with Union Oil Co. of Calif., who was elected to Council of Pacific Petroleum Chapter for 1949.

Officers of the Junior Group For 1949

C. T. McClure	*Chairman*
Irving Dagan	*Secretary*
R. L. Parsons	*Treasurer*
Norman B. Clark	*Programs*
Al Marshall	*Membership*
Ted Mitchel	*Ex-Officio Member*

★ ★ ★

Pacific Chapter Activities (Continued)

The performance of the Erburu is that of a normal depletion type reservoir. A small initial gas cap may have been present. Shutting in wells appears to have caused considerable permanent reduction in capacity to produce. This was ascribed to hydration or deflocculation of clays in the oil sand by water infiltration from the well bore. Gas injection has been attempted on two different occasions with rather promising results, but due primarily to the divided ownership of the field and the necessity of having pressure contours conform to property lines, gas injection was abandoned. Little difficulty was experienced in by-passing of injected gas, even into wells closest to the injection wells. ★ ★ ★

Three members of the panel on reservoir engineering for the January 13 meeting of the Junior Group. Left to right: R. L. Parsons, Calif. Research Corp.; Oran A. Graybeal, Barnsdall Oil Co.; and M. B. Standing, Calif. Research Corp.

Southwest Texas Section Activities

By Raymond Keller, Jr.

The monthly meeting of the Southwest Texas Section was held on January 12, 1949, in the Terrace Room of the Robert Driscoll Hotel. In view of the inclement weather—we don't say cold or rain in Corpus Christi—the turnout of 94 members and 103 visitors was indeed gratifying. The group began taking their usual setting up exercises on the brass rail at 6:30 p.m. and after working up a good appetite sat down to dinner. Following supper, the meeting was formally called to order by Chairman Raoul Bethancourt of the Sun Oil Company. He in turn presented the speaker of the evening, W. O. George of the United States Geological Survey, Austin, Texas.

Raymond Keller, Jr., *Journal* Secretary for Southwest Texas Section. A native of San Antonio and graduate of Univ. of Texas. Worked in various capacities for Penelas Mining Co., Humble Oil & Refining Co., and the California Co. from 1934 to 1938. Served with 36th Div. during war; wounded in Italy. Now petroleum engineer in Corpus Christi office of Seaboard Oil Co.

Charles H. Snelson, left, and R. C. Granberry, Jr., right, vice-chairman and secretary-treasurer, respectively, of the Southwest Texas Section.

George's paper, "*Underground Waters as Related to the Oil Industry*", was of great interest to all. While this section of the United States is not yet in as dire need for water as some sections, the supply is diminishing and the demand increasing. Hence the problem of water supply is of vital importance if Southwest Texas is to continue its industrial expansion. George related in his paper that in all parts of West Texas there were now water lease hounds who followed the current play, leasing water rights with the intention of selling water for drilling purposes. There is no law in Texas to force conservation of water or to protect the interest of any person who wishes to conserve the water supply on his property. As a result of this lack of control, the Railroad Commission, the United States Geological Survey, and the State Water Board, which are now closely integrated in their attempts to protect fresh water, can only ask whole-hearted cooperation of the oil industry in efficiently carrying out their program. One source of fresh water which has not yet been tapped is the deeper sands of the Carrizo formation. This water, while more costly due to deeper drilling and much higher temperature, is fresh and can be used. It was pointed out that, contrary to popular belief, this sand is below many salt water sands. George predicted the eventual proration of water in his summation.

At the business meeting which followed, the problems of holding the fall meeting of the Petroleum Division were discussed. The Southwest Texas Section is to be host to this fall meeting which will be held in San Antonio.

Southwest Texas Personals

Raoul Bethancourt, area engineer at Freer for Sun Oil Company, will make the trip to San Francisco for the annual meeting. Bethancourt also attended the meeting last year in New York.

Charles H. Snelson, district superintendent for Seaboard Oil Co., Corpus Christi, is in the Hermann Hospital in Houston recovering from a severe heart attack. His many friends will be glad to know that his condition is improving, and that he hopes to be able to leave the hospital soon.

Ed H. Lancaster, Jr., senior petroleum engineer in charge of drilling and mud operations for the Corpus Christi District of Humble Oil and Refining Co., is resigning to accept the position of chief engineer for Magnet Cove Barium Corporation.

James Doughty, vice-president in charge of operations for Southern Minerals Corp., has resigned his position effective February 1. He will be part owner and in charge of operations for the Rencon Drilling Co.

Among the out-of-town visitors at the January meeting of the Southwest Texas Section were **T. G. Garwood,** Otis Pressure Control, Inc., Houston, Texas; **Ernest G. Hotze,** Clark Brothers Co., Inc., Houston, Texas; and **Jack Storey,** Republic Natural Gas Company, Dallas, Texas. ★ ★ ★

R. J. Bethancourt, chairman of Southwest Texas Section for 1949.

Book Reviews

(The) RISE OF AMERICAN OIL

By L. M. Fanning. rev. ed. Harper & Brothers, New York and London, 1948. 178 pp., 8½ x 5½ in., cloth, $3.

Written for the layman, this book puts petroleum in focus with social and economic history. It considers the effect of petroleum on progress and mechanization from the opening of the Pennsylvania oil fields through modern uses in war and peace. Outstanding inventions and applications are described. One chapter deals with synthetics and substitutes.

EXAMINATION AND VALUATION OF MINERAL PROPERTY

By Roland D. Parks. Addison-Wesley Press, Inc., Cambridge 42, Mass. 425 pp., Illustrated. Convenient Handbook Style. Flexible Cloth Bound, 4¾ x 7⅛.

A lucid discussion of the procedure of the examination, the collection of data, and the calculation of the valuation of mining property, with applications helpful in commercial valuations. This is the Third Edition of the original Mine Examination and Valuation by Baxter and Parks. It has been thoroughly revised and expanded to cover evaluation of oil property, treatment and marketing of complex lead-zinc ores, standard sampling practices, and the geological field investigation.

OUTPUT AND PRODUCTIVITY IN THE ELECTRIC AND GAS UTILITIES 1899-1942

By J. M. Gould. National Bureau of Economic Research, New York, 1946. 195 pp., charts, tables, 9¼ x 6 in., cloth, $3.

This book presents new measures of output, employment, fuel consumption, and capital investment in the electric, manufactured gas, and natural gas utilities. The changing relation of output to the use of the various resources—labor, fuel and capital—is described. The movement of electric and gas output and each of the input factors is traced since 1900. Retardation in rate of growth is discussed and compared with similar characteristics of other industries.

REVIEW OF PETROLEUM GEOLOGY IN 1947

By F. M. Van Tuyl, W. S. Levings, and L. W. LeRoy. Published in the Quarterly, Vol. 43, No. 3, Colorado School of Mines, Golden, 334 pp. $3.

This sixth annual review is based on information compiled from the literature and from a canvass of leaders in petroleum exploration in the United States and foreign countries. Covered are important events of the year, advances in petroleum geology and contributory fields, including developments in the training of geologists and geophysicists, progress in the developments in geophysics and geochemistry, developments in petroleum engineering, aerial photographs, new and improved techniques, world exploration and development, production and reserves, trends in petroleum geology and geophysics, and the future of the petroleum industry.

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Oklahoma City Section

Continued from page 9

Anderson-Prichard Oil Corp. has opened a division office in Denver for exploration and development in the Rocky Mountain area. **John Maxon,** formerly of Bay Petroleum, has been placed in charge. The Anderson-Prichard Production Department, all key personnel of which are members of AIME, has moved into new and larger yuarters in the APCO Tower, Oklahoma City.

Don Smith, formerly with Halliburton Oil Well Cementing Co., is now employed by Skelly Oil Co. and located at their Velma, Oklahoma, camp. **Ed Koons,** formerly with Halliburton, is now with the Department of the Interior and is in Dallas temporarily for a training course.

Albert R. Greer, formerly district engineer for Anderson-Prichard Oil Corp. in Hobbs, New Mexico, has been transferred to the APCO production office in Oklahoma City and is devoting full time to reservoir analysis and evaluation.

Sam B. Lisle, mechanical engineer, has transferred from the West Edmond Unit to Sohio Petroleum Company, Oklahoma City. ★ ★ ★

Mid-Continent Section

Continued from page 13

which time further nominations may be made. Ballots will be sent out as soon as possible, with a deadline of April 1, 1949, for ballot returns.

Mid-Continent Personals

H. R. Bolton, division petroleum engineer, Ohio Oil Co., Tulsa, has been transferred to Marshall, Illinois, as division petroleum engineer of the Terre Haute Division. **R. E. McMillen,** formerly district engineer at Midland, Texas, has been transferred to Tulsa, replacing Bolton. **Sylvain J. G. Pirson,** formerly professor of geophysics and geochemistry at Pennsylvania State College and an authority on reservoir engineering, recently has become affiliated with Stanolind Oil & Gas Co. in Tulsa, as special research associate, production research department. ★ ★ ★

Fellowships Granted by Gas Technology Institute

Two year fellowships leading to the degree of Master of Technology, and four year fellowships leading to the degree of Doctor of Philosophy are now available through the Institute of Gas Technology. Selection will depend upon demonstrated academic ability in chemistry, physics and mathematics, along with demonstrated leadership and character. Applications will be accepted from senior students in the science and engineering fields who are under 28 years of age. The stipend begins at $125 monthly.

Further information may be secured by writing direct to The Director, Institute of Gas Technology, Technology Center, Chicago 16, Illinois.

MEMBERSHIP OF PI EPSILON TAU AT UNIVERSITY OF OKLAHOMA

Petroleum engineering students, who predominate in the engineering school of the University of Oklahoma, formed the first chapter of Pi Epsilon Tau, an honorary petroleum engineering fraternity, in November of 1947. It had become a recognized campus organization within a year.

FIRST ROW, L. to R.: Henry G. McKaskle, St. Pat's Rep.; Milton P. Christensen, corr. sec.; William G. Sole, Jr., 2nd vice-pres.; Robert Penner, pres.; Dr. John C. Calhoun, sponsor; Preston Rannie, exec. vice-pres.; James Murdock, sec.-treas.

SECOND ROW, L. to R.: John Jones, Jr., Joe H. Templeton, E. A. Ernst, Preston L. Moore, Aubrey M. Baker, B. David Meltzer, Robert E. Bennett, Loyle P. Miller.

THIRD ROW, L. to R.: O. C. Person, C. W. Peter, K. N. Thomas, E. H. Whitlock, Loy M. Hembree, Charles W. Hickok, Morris Todd, T. G. Ward.

FOURTH ROW, L. to R.: James R. Nolan, Lyman M. Rasmussen, Ralph S. Treadwell, George E. Kunkel, C. L. Franke, George T. Higginbotham, J. M. Daley, Everett H. Parker.

FIFTH ROW, L. to R.: William J. A. Johnson, George M. McKown, Hermond Ledbetter, Michael A. Luby, Donald O. Powell, Willard G. Brill, Bob Searth, John D. Kimmel, James R. McLaughlin, George W. Atchley.

INSETS: Two views of pledges securing member's signature, which is a part of the pledge duties during pledge week.

North Texas Section

Continued from page 15

Another area of controversy and growth in the oil and gas producing business centers around cooperative producing activities and unitized operations of oil and gas reservoirs. Conservation regulations tend to minimize the importance of an individual lease. Voluntary and so called compulsory unitization is now an established feature of our industry and a distinct conservation device.

The speaker reminded all engineers and geologists present of their heavy role in many business decisions and in the whole structure of our conservation system. As a word of warning he advises engineers not to depart from their role as men of science devoted to the "truth, the whole truth, and nothing but the truth."

North Texas Personals

E. R. Brownscombe, associate director, production research, The Atlantic Refining Co., Dallas, Texas, has returned from what he described as a very interesting six weeks stay in Venezuela. He arrived November 15, and the President of Venezuela was jailed on the 16th; however, he denies any implication.

George Y. McCoy, for several years a petroleum engineer for Republic National Bank of Dallas, has announced the opening of consulting offices in the Empire Bank Building, Dallas. McCoy, who is a former member of the faculty at the University of Texas, will specialize in reserve estimates and evaluation.

George D. Ramsey, vice-president and general manager of operations, Lone Star Steel Co., Daingerfield, Texas, has moved from Longview to Dallas.

Francis L. Lee, petroleum engineer, Shell Oil Co., Wichita Falls, Texas, resigned to accept a position with Union Pacific in California.

John T. Gary, district petroleum engineer, Continental Oil Co., Wichita Falls, Texas, was transferred to the Ponca City office. **J. A. Moore** replaced Gary as district petroleum engineer, Wichita Falls. ★ ★ ★

Muskat Presents Lecture at Texas U.

Reservoir engineering was the topic of a three-day lecture series by Morris Muskat of Pittsburgh at the University of Texas on February 8-10. Muskat is chief of the Gulf Research and Development Company's physics division.

The series was presented under the sponsorship of the petroleum engineering department of the University, and included lectures on relative permeability, condensate reservoirs, gas drive performance, gas inejection, water injection, well histories in water flooding, and partial water drive.

MEMBERSHIP OF PI EPSILON TAU AT UNIVERSITY OF OKLAHOMA

Membership of the fraternity is composed only of graduate and undergraduate petroleum engineering students, and a selected group of honorary members chosen from P. E. graduates with outstanding achievements. The O. U. chapter aspires to becoming a national organization.

FIRST ROW, L. to R.: William W. Owens, Paul S. Johnston, Prof. G. D. Maddox, Prof. Nico Van Wingen, Prof. Howard W. Benischek, Homer C. English, John P. Everett.

SECOND ROW, L. to R.: J. D. Harrington, Charles R. Olson, Bob Cassingham, Bob Sears, John W. Harris, Jr., Carroll F. Mahoney, Leniford J. Willis, J. L. Sanders, Hiram W. Keith, Charles Kern.

THIRD ROW, L. to R.: Virgil L. Stoabs, Marsh S. Watson, Raymond J. Schneider, H. V. Ward, Stanford L. Downs, Arthur E. Creamer, Bill Tucker, Jim Spalding.

FOURTH ROW, L. to R.: Gene C. Bankston, Willis B. Rummel, R. Roethke, Spencer L. Taylor, Vancle E. Dykes, J. C. Willis, J. Pat Kidd, James G. Lineham, W. H. Malcolm, Herbert M. Channell.

FIFTH ROW, L. to R.: Landon B. Kelley, Harold M. Seeley, Francis H. Ahrnsbrak, J. W. Vater, Jr., Clifford L. Banks, Earl G. Thurman, Jr., James H. Stanley, Frederick V. Miles, Forest J. Allen, Jr., Archie M. Speir.

INSETS: Left—Pledges saluting member during pledge week; Right—Pledge raising pledge flag atop one of the derricks on the university campus.

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♦ Reservoir Engineer — Experienced reservoir engineers including specialist in secondary recovery problems on both water and gas.

♦ Wire Line Operator — Man experienced in wire line work to operate bottom-hole sampling truck and perform some related laboratory work.

For reply to all of above write direct to Continental Oil Company, Personnel Division, Ponca City, Oklahoma. State experience, education and salary expected.

SOME ASPECTS OF OUR FUTURE MINERAL SUPPLIES

W. E. WRATHER, PRESIDENT AIME, DIRECTOR U. S. GEOLOGICAL SURVEY, WASHINGTON

Our future mineral supply is a matter which is vital not only to our national security but also to our continuing industrial development. The recent war obliged us to use our natural resources unstintingly without thought of the future. The present unstable peace is an added spur to take a critical look at our available mineral supply and thoughtfully consider what the future may hold for us.

Industrial activity did not slacken at the end of the war as was generally expected; there was scarcely a pause in the upward trend. Mineral raw materials are being consumed today in ever increasing quantities, and scarcities have developed on every hand.

Present trends in mineral consumption may be construed as largely due to abnormal conditions following in the wake of war. We are making up arrearages in consumer goods, in housing, and are rehabilitating and reconditioning industry and agriculture to serve an increasing population. At the same time we are aiding, through the Marshall plan, the reconstruction of the war-torn world. It is difficult, even impossible, to segregate and make allowances for these abnormalities. If the assumption is correct that the present industrial boom is to be a considerable extent the result of the war, we might logically expect that the demand for minerals will decline when arrearages have been satisfied, and when the world has returned to anything approaching a self-sustaining basis. On the other hand, an increasing domestic consumption must be anticipated, if we are to have full and gainful employment for our rapidly increasing population and maintain a peace-time status of military preparedness adequate to ward off aggression. How long the present upward swing will continue is anybody's guess, in view of the unsettled economic and political state of the world.

CURRENT MINERAL CONSUMPTION GREATER THAN EVER BEFORE

It has been stated by competent and conservative students that the world has consumed more of its mineral wealth in the present generation than in all previous history of mankind. This startling statement might be hard to prove statistically, but enough supporting data can readily be cited to prove that it is well within the range of probability. Many individuals have only to resort to their personal experience for proof of the approximate accuracy of the statement. A generation is a very short period in the life of a nation.

It is true that two devastating wars are included in this period, but there is little doubt that we would have arrived at our present position in a somewhat longer period, even without the forced draught of war demands. Industry requires the same raw materials for either peace or war. Can we safely assume that the upward curve of mineral consumption will be extrapolated into the future? Sooner or later it may be expected to flatten out, but consumption will even then be prodigious. Where are any such quantities of minerals to come from?

Advancing technology and intensified industrial development have coincided with the period of greatest mineral consumption. It is difficult to determine which of these factors is cause and which is effect. In any event, they have progressed hand in hand and have been interdependent. Each new advance in technology has created new needs for minerals instead of relieving us of our dependence on them. Witness the enormous tonnages of steel, copper, lead, and the massive construction required to harness the products of atomic fission; the imposing and delicately balanced structure on Mt. Palomar, which is the price we pay in materials and workmanship for a more distant glimpse of the universe; the elaborate plant construction required for the proposed synthetic fuels program; or even the diversion of the very substantial tonnage of steel to provide the facilities for an expansion of steel production. The increasing use of electricity has called for more and more copper. Air transportation advanced the aluminum industry in a short period from minor to major proportions. Steel is basic for almost any new development and the demand appears to be boundless. Meanwhile fuel resources are consumed at a correspondingly increased pace to supply the energy for our mechanized civilization. It is reasonable to expect, on the basis of past experience, that there

will be no early let-up in the demand for minerals, as long as there is any reasonable prospect of securing them in adequate quantities at an acceptable cost. The problem of exceeding or even maintaining the present volume of production is a challenge to the wit and ingenuity of the several segments of the mineral industry.

PAST AND PRESENT OF THE PETROLEUM INDUSTRY

First let us take a look at the petroleum industry, now about ninety years old. For the first half of its existence, its efforts were devoted primarily to suppling illuminating oils. The lighter fractions of the crude, including gasoline, were a nuisance; they were removed and disposed of as waste products. The volume of crude required to meet all needs could readily be assured by random and undirected wildcatting. Then around the turn of the century many of you recall as I do, the first appearance of the automobile on the American scene. The perfection of the internal combustion engine furnished a market for the hitherto superfluous gasoline, and the oil industry was thereby given a tremendous impetus.

When gasoline first found a market in the early 1900's, the daily crude oil production averaged around 250,000 barrels daily, figured on an annual basis. This date coincided approximately with the discovery of salt dome production in the Gulf Coast, which thenceforth added an increasing increment of heavy gravity crude, then considered suitable only for fuel oil. Domestic production increased steadily and at a relatively constant rate through succeeding years, but not until after the end of World War I, in 1919-20, did it reach a daily average of 1,000,000 barrels. Despite the oft repeated statement that the Allies floated to victory on a sea of oil, there is no evidence in the production record that any strain was thrown on our productive capacity. The impact of the war drove the price of light gravity crude upward to $3.50 per barrel. The high price accelerated wildcatting which sustained a continued increase of production over a postwar period when a severe slump might otherwise have been anticipated. The expanded use of oil brought about by the war carried forward into peacetime, and production established a new base line which was thereafter annually exceeded even during the years of the succeeding depression.

It was generally believed that the daily production of 4.8 million barrels, attained at the height of World War II, would stand as a record, for at least several years to come. Instead there has been an uninterrupted increase to the present figure of around 5.5 million barrels. This is a repetition of the pattern which followed the First World War, although there is room for argument as to whether it is due to precisely the same causes. Within a period of thirty years there has been a 5½-fold increase in daily crude production with every indication that the upward trend will continue for some time to come. The increase is fundamentally even greater than these bald statistics indicate, because of the continued improvement in production practices, refining and utilization which have resulted in each barrel of crude yielding more effective work as the years go by.

The Importance of Technology

It is unnecessary to dwell here on the impact of science and technology on the industry during this thirty year period; the increasing effectiveness of geology and geophysics in exploration; the improvements in metallurgy, design, and operation techniques which have contributed to ever increasing drilling depths; the conservation of gas and the control of reservoir energy to secure more efficient primary recovery of oil; the evolution of the concept that the component molecules of hydrocarbons can be torn apart and controlled by manipulation of heat, pressure, and catalysts to form products not present in the natural crude. These developments have been accomplished largely by men still active in the industry and need no elaboration.

For the past ten years the discovery of new domestic oil has not kept pace with consumption. We have a very substantial proven reserve, but if discovery continues to lag, the reserve will increasingly consist of partially depleted properties which cannot respond promply to a heavy and sustained draught in case of an emergency. The present price of oil has greatly accelerated exploratory drilling, which will no doubt increase the discovery rate and temporarily at least improve our position. I am not too sanguine, however, that production will long be able to keep pace with consumption, if consumption continues to expand at the present rate. Undoubtedly we have large undiscovered reserves but they are probably chiefly confined in stratigraphic traps or thoroughly concealed structures which cannot readily be detected by present geological and geophysical techniques.

Our concern about a possible oil shortage grows primarily out of consideration of national defense. If political conditions permit of anything approaching normal international trade, we need not worry about the immediate future. Our domestic reserves plus those of the Caribbean and the Near East can supply all reasonable needs for many years to come.

If, however, we should again be long shut off from the balance of the world, we may be compelled to resort to synthetic liquid fuels as a collateral source of supply. We have the great consolation of an abundant supply of raw materials from which synthetic liquid and gaseous fuels can be made, and we have the technical and scientific competence to handle the operation. In the light of present knowledge, a synthetic fuels industry capable of meeting our anticipated needs, superimposed on our present industrial economy, presents staggering requirements of manpower, expense and construction materials. At best it can offer substantial relief only in a period of years. The problem must be subjected to the most critical analysis to determine both the most efficient and economical processes, and to simplify and improve plant design. The substantial heat losses incident to all the known processes are a most important consideration which must be weighted against the value and need of the products obtained. Our own experience and that of the Germans indicates that synthetic fuels are a last resort only after sufficient natural products are no longer available. Fortunately both industry and Government are acutely aware of the urgency of evaluating and mastering the new techniques without delay.

STATUS OF OTHER METALS

I have dealth thus far mainly with one mineral commodity—oil—which, in the light of present knowledge, presents few problems we cannot hope to solve satisfactorily, granted the time to accomplish an orderly transition to new techniques. Let us next consider the status of the metals. Don McLaughlin has recently very effectively summarized the status of the metals, and I take the liberty of quoting from his statement:

"We are, as I see it, in a major period of transition in our economy from a time when there were large surpluses of nearly all major mineral products, including petroleum, that were available for export, to a period when our production capacity must be supplemented with imports from abroad, not only of the rarer minerals and most of the alloy metals that we have long recognized as shortages, but even for the common metals and petroleum itself with which we are so well endowed.

"To recognize these trends, particularly as they pertain to our own immediate welfare, is essential. It does not require the acceptance of the much debated view that we are now a 'have-not' nation, but only the blindly optimistic can fail to realize that *in relation to the present demand* our known mineral reserves are dangerously low and the rate of replenishment through discovery is far slower than in the past—and far from enough for security in these worrisome times.

"Our history has not conditioned us too well for the change from a past of abundance to a future of relative scarcity—i.e., from a time when consumption was more of a problem than reserves of raw materials, to a period when the demand for minerals and their products is not easily met even with the nation's well developed and energetically worked mining districts. At the outbreak of the First World War, our dependence on sources outside our own borders was so slight that the term strategic mineral had hardly been invented. Tin, chrome, and manganese were almost the only serious deficiencies, as the demands for special steels at the time had not become critical enough to make our weaknesses in many of the allow metals too apparent.

"The first war shook our complacency a bit, but with the whole world outside the borders of Germany and Austria available to us, the full risk and dangers of lack of essential ores and fuels were not brought home as forcibly as they should have been. The war ended with surpluses of metals and fuels, and the economic headaches resulting from them overshadowed the more fundamental problem of ultimate supply.

"And again when war came and again when we had time to prepare behind the shield of the British Empire, the list of materials we lacked seemed small—perhaps a dozen minerals—but before the end of the wasteful conflict it had more than doubled, and there was scarcely a single major metal that was produced within our borders in sufficient abundance to relieve us entirely of dependence on foreign sources, in spite of pushing our domestic operations to new peaks.

"Contrary to the prevailing expectation, the transition from war to peace this time did not result in surpluses. Indeed just the opposite occurred. The demand for both metals and fuels actually has increased to such degree that in many cases even the relatively meager stockpiles, which we had on hand at the end of the war, have been drawn to virtual exhaustion.

"Even if peace were certain for the next century, the situation with regard to minerals and fuels needed for the expanding industries of the time should call for most serious thought as to ways and means of meeting the nation's requirements. And now, with hasty rearmament and restocking of materials for war again harshly imposed upon us, the urgency of the problem is compounded."

There is little room for disagreement with this thoughtful statement. What course of action is indicated if we accept this philosophy?

In the interest of national security, stockpiling of strategic and critical minerals is now provided for by statute, although there has been some delay to avoid too much interference with the free flow of mineral commodities to industry for reconstruction. There is general agreement that stockpiling by the government should proceed vigorously, but the Congress is now considering whether preferential treatment should be given to domestic producers to encourage the development of marginal, low-grade deposits.

WAYS TO BECOME SELF-SUFFICIENT IN MINERALS

What are the prospects of achieving anything approaching self-sufficiency for the long-range needs of industry? Among the more frequently mentioned means to this end are:

1. Discovery of additional sources of supply.
2. Utilization of low-grade marginal deposits.
3. Greater economy in use.
4. Substitution.
5. Recovery of scrap.

Here are a few broad generalities from the viewpoint of a geologist with regard to the discovery of additional sources of supply.

1. With few exceptions the present important mining districts were discovered by detection of mineralization in surface outcrops and most of them have been known for years. Persistent prospecting of the surface in recent years has uncovered few additional mineralized districts of major importance. To a geologist it seems inconceivable that all mineralization within mineable depth should be evidenced at the surface. The present land surface is the result of only the more recent episodes of earth deformation. It is illogical to assume that the vicissitudes of erosion have exposed more than a portion of the recoverable mineral wealth. A geologist, therefore, must of necessity conclude that we have in this country a very substantial reserve yet to be discovered.

Geological exploration techniques must be oriented to the search for obscure, buried ore bodies. Geophysics can probably be developed to play a more substantial and effective role in ore discovery. The usual complex geology of ore deposits admittedly presents more difficult geophysical problems than the comparatively more simple sedimentary geology of the oil regions; but persistent research can reasonably be expected to pay dividends.

Likewise, geochemical exploration offers a promising field of research. Significant changes in the mineral content of surface and underground waters; in the residual soils; or even in the fiber of growing plants may serve as effective guides to areas of hidden mineralization, just as float in a stream bed may be trailed to locate an outcrop.

Meanwhile the proven technique of general geologic mapping, should be prosecuted with all vigor as a dependable means of directing attention to areas of greatest potential promise. Only a small fraction of the country has thus far been adequately mapped.

It would be unwise to too lightly write off the mineral potentialities of the geologically less known areas of the country in view of the instances which might be cited of discoveries of both oil and mineral deposits traceable to fragment- and obscure geological data which might easily have been overlooked. A comprehensive program of geological exploration is thoroughly justified by the prospects of success. Whether discoveries will be commensurate with the needs of the day will depend upon imponderables of price, of advances in mining methods, beneficiation, and metallurgy; availability of labor, and other factors upon which it is useless to speculate.

2. Low-grade marginal ore deposits are primarily relative designations, valid only as to time. The low-grade ore of one generation becomes the high-grade ore of another, just as tailing dumps usually move into the class of ore with the lapse of time. If the urgency of need is sufficiently great to justify the cost and effort, means can usually be found to utilize low-grade ores which in the case of some minerals occur in great abundance. If high-grade aluminous clays could be treated cheaply enough, we could avoid the import of bauxite. If lower grades of iron ore can be cheaply beneficiated, we need have no apprehension as to supply for generations to come. The low-grade ores of today may become a substantial national asset of the future and they must not be ignored.

3. War shortages taught us some valuable lessons in economy of use. Our dwindling stockpile of tin led to the development of an electroplating process which reduced by 60% the requirement for tin plate with little sacrifice in quality. When enough clear quartz crystal for oscilator plates could not be stirred up despite diligent scouring of the far corners of the earth, persistent research demonstrated that previously rejected grades could be used. When some of the ferro alloys could not be had in sufficient quantities, it was found that controlled heat treatment imparted acceptable physical properties to steel. In all probability we have a great deal more to learn about economy of use of metals which will enable us to do with less.

4. Chronic shortage or high price of a commodity inevitably leads to persistent search for a substitute. Thus far we have never been forced to resort to substitutes to any appreciable extent except during the last war. War shortages led to many substitutions, but there has been a tendency to return to earlier patterns of use when customary supplies were again available.

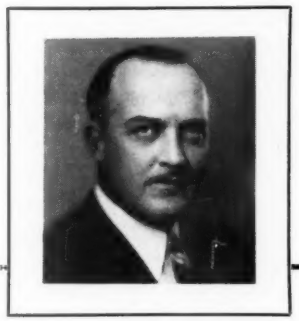
Diligent research to discover substitutes usually unearths new information which leads to new industries. Although one metal may be satisfactorily substituted for another for certain limited uses, enough new uses are soon found to absorb the available supply of both. Here again, new knowledge resulting from research leads to ever greater demands for minerals, even though the research was instigated to offset a shortage. The possible effect of substitution on stretching available supplies cannot be evaluated until it has been given a more thorough and searching trial.

5. Most metals are indestructible. Aside from wear and tear most of them are available for re-use by succeeding generations. The secondary recovery of the base metals is today a very substantial part of current supply. Shortages of scrap is one of the prime reasons for the present shortage of steel. We have until recently been a notoriously careless nation in recovery of scrap, but with scarcity and resulting increased prices we are rapidly mending our ways. The scrap industry is today a far cry from the junk men of the recent past. Special alloys occuring in scrap must be carefully assorted and classified before re-use, to insure the quality of the finished product. The reservoir of metal in use, which will eventually return in the form of scrap is constantly expanding. With the lapse of time it offers an increasingly important safeguard for the future.

Our generation has witnessed a domestic production of irreplaceable mineral resources which is little short of explosive in relation to previous history. This rate of increase of production cannot continue indefinitely. If we can supplement domestic production with imports from abroad, our industrial development can continue to expand for un unpredictable period; but with the insistence of the more backward nations for participation in improved standards of living, we may expect that they will increasingly resist selling us their raw materials, as England is now realizing to her great discomfort. We must, therefore, make the most of our own resources.

UNPRECEDENTED RESEARCH NECESSARY

The commonly accepted hopes for attaining self-sufficiency have been briefly outlined above, but we must recognize that if we are to convert these hopes to realities, we must support research for new knowledge on an unprecedented scale. We have faith that additional reserves remain to be discovered, but we have not yet developed techniques adequate to the task. We know we have large reserves of low grade mineral deposits, but we have not mastered methods of mining, beneficiation, and metallurgy to bring them into commercial production. We know all too little about the possibilities of substitution or the most economical use we can make of available supplies. We have been profligate in our waste of metals after their primary use. We have become so accustomed to abundance that we have developed spendthrift habits which will be hard to break. Only emergency and dire necessity will force us to support research on a scale commensurate with the need. The moral is clear—the mineral industry must give both moral and financial support to an accelerated program of research in all phases of exploration, extraction, processing and utilization. It is our surest safeguard for the future. ★ ★ ★



SOME ASPECTS OF UNITIZATION—CALIFORNIA OIL AND GAS FIELDS

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INTRODUCTION

The purpose of this paper is not to engage in any technical discussion of engineering problems, but, on the contrary, is intended solely to outline certain basic concepts of the economics of oil field operations as viewed by management.

There are so many phases of operational benefits that, for simplicity, I shall confine my remarks to a specific —and too often controversial—group enterprise method of pool operation. The most common of several optional methods is that practiced under the familiar arrangement known as pool unitization.

DEFINITION OF UNITIZATION

The word "Unitization" as applied to oil and gas pools is one which has grown out of industry usage and will not be found in dictionaries. In practice, the word refers to the "unifying" or "pooling" of working interests and mineral interests underlying the lands in a particular oil or gas pool, or field, upon an agreed basis, for the purpose of developing and operating such lands as a single unit without regard to ownership or division of ownership in particular tracts or parcels of land. There may or may not be cross assignments of working interests and mineral interests underlying individual tracts of land making up the unit. The agreement must provide for allocation of production and expenses upon the agreed basis and the agreement should clearly indicate the intention of the parties to "unitize" their ownerships. Notwithstanding that the word "unitization" does not appear in standard dictionaries, practically every unit agreement provides that the parties to it "hereby unitize" their interests in the properties subject to the unit, as though they were a part of a single lease or property.

Briefly I shall try to cover the overall progress of, and the benefits derived from unitization efforts by various elements of the oil industry during the last few years in California. To some extent, I shall also discuss the future and the degree to which additional benefits may be expected.

RECOGNITION-APPRECIATION OF BENEFITS

Most of the oil fraternity and many outside of its recognize the benefits of unitization, some to a greater extent than others. The more foresighted members of top management have long since come to the realization that typical depletion methods of operation in many instances make it impossible to secure the greatest economic recovery of oil and its associated hydrocarbons. Such customary methods as were generally followed over a period of years were evolved largely in an era of plenty and in an atmosphere of robust competition almost entirely devoid of customs or laws regulating oil and gas industry operations.

During more recent years, however, as a result of increasing experience and improved technology, petroleum engineers and geologists have learned more and more about the behavior of oil and gas pools and the type of production program best suited to a particular pool. Fortunately, engineers and geologists can analyze these problems from an objective viewpoint. They can and do think in terms of sound oilfield engineering practices without regard to possible legal complications or individual attitudes. The legal precepts under which the oil industry grew up were not designed to require conformance with what are now regarded as good oilfield engineering and conservation practices. Thus, they are out of date in the light of present day engineering knowledge and practice. It may therefore be necessary to overhaul our legal machinery and bring it abreast of the engineers. I shall discuss this point later.

Landowners, as a general rule, have not recognized the benefits to be derived through unitization. For the most part this is due to an almost complete lack of understanding of fundamentals. The large landowner, however, has had the incentive and taken the time to give the subject serious thought and in many

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cases has, of his own accord, obtained competent engineering advice. Accordingly, he is more apt to appreciate the benefits to be derived from a more enlightened approach to common pool problems. The Federal Government and the governments of some of the states, as landowners, have also recognized these factors. The public as a whole is not familiar with either the purpose or results of unitization. It is worth considering whether an educational program should be developed as a part of the petroleum industry's public relations activity, pointing to the public benefits which may be achieved by unit operations.

APPRAISAL OF BENEFITS

It is readily apparent that the benefits to oil operators from unitization are of two kinds: (1) the saving in development and operating costs, and (2) the expectation of insuring greater ultimate recovery from a given pool.

The extent of monetary savings in development costs will largely depend upon when the pool is unitized. It will be agreed, I believe, that large expenditures can be saved in drilling activities alone by unitizing before the pool is fully developed.

As to the major factor of anticipated greater ultimate recovery, each pool will present a special problem and require individual analysis. It is unnecessary to tell you that unitization, pressure control or secondary recovery are not necessarily "cure-alls" which can be applied to all pools. In many instances it may well be concluded that normal depletion methods will bring about the greatest ultimate recovery.

Nevertheless, let us take a pool which according to engineering determinations should be unitized. The physical factors indicate the opportunity for greater ultimate recovery. It is then the duty of the engineer to give his opinion as to the additional amount of oil and associated hydrocarbons which may be recovered through such operations and the comparative economics involved. Engineers may differ, and properly so, in their estimates. No one can definitely prove his figures; these calculations are relative but are the best available, predicated on sound engineering opinion, and, with present techniques, reasonably demonstrable.

With these engineering data leading to a conclusion that more oil will ultimately be recovered at less cost through such operations, a decision must be made on that basis rather than on absolute assurance that a definite number of additional barrels will be recovered. In other words, the matter then becomes a business decision by top management and involves some element of risk.

Based on experience with pools discovered in more recent years and susceptible to pressure control operations, management is thinking in terms of a general average of 10% to 20% greater ultimate recovery under unit operations, compared to what would have been produced under normal depletion methods. While these percentages cannot be applied with impunity to all such pools, I beleive they are reasonable. Consequently, unit plans projects can be of tremendous importance from the standpoint of petroleum recovery, and often offer the cheapest source of additional reserves.

PROGRESS

Notwithstanding the practical problems attendant upon completing voluntary unitization projects, real progress has been made in California in the last several years. Actually, we have every right to be proud of our record, notwithstanding uninformed external criticisms and our own admitted problems. Among others, unitization plans have been placed in effect in the Canal, South Coles Levee, Helm, Greeley, Rio Bravo and Elk Hills fields in the San Joaquin Valley and in the West Coyote field in the Los Angeles Basin. Pressure control operations are being conducted in all of these fields except Helm. The Coalinga Nose and Salt Creek plans are nearing fruition and negotiations are currently being carried on to unitize Northeast Coalinga and the 27-B Pool at Buena Vista Hills. Pressure control operations undoubtedly will be conducted in these pools.

Altogether, the unit operations just enumerated represents a sizeable portion of the oil reserves in California. This in itself is indicative of the importance of the projects and of the sincerity with which operators approach these mutual problems.

TIME ELEMENT IN DEVELOPING A PLAN

Notwithstanding the current record of ten California fields either unitized or in the process of unitization, the time required to develop and consummate a unit plan under voluntary methods is substantial. Let us examine some of the reasons why it takes so long.

Early in the life of a pool, as stated before, engineers can come to a reasonable conclusion whether it is desirable to unitize and whether a pool is susceptible to pressure control operations. If the answer is positive, the engineer makes a recommendation to his management. In the meantime, development of the pool progresses. There may be several operators; each will normally proceed to drill his individual properties with his own organization. Concurrently, each operator must make up his mind whether he wishes to participate in the project.

With all or practically all of the operators willing to unitize, there are then the problems of the basis for, and percentages of, participation to be agreed upon; the method of revising the percentages; who shall be the operator for the unit; what are the participants' voting powers and how shall they be measured; and a host of other problems. Each item takes a great amount of time and inevitably requires endless meetings of engineers, lawyers, accountants and others before accord is finally reached. Most of these questions must ultimately be resolved by management. Many, particularly those of percentage participation, are reasonable compromises. But while time is thus consumed, real benefits are being lost in ultimate recovery.

LEGAL ASPECTS AND LESSORS

Even with agreement among the participants, there yet remains the problem of selling the project to landowners and royalty interests.

If there is divided ownership of land in either working or royalty interest in

a pool, it is impracticable to carry out pressure control or secondary recovery operations without unitization. First, there is the matter of lease requirements which contemplate individual development and operation. Second, there is the possibility of legal action resulting from complaints that pressure control or secondary recovery operations will result in adverse disturbance of reservoir conditions. It is for these basic reasons that unitization is advisable, if not necessary, from a legal standpoint.

Thus, with legal limitations and in the absence of statutory authority, these problems must be met by negotiation. This will involve agreements modifying lease provisions and relieving the operator from liability from possible disturbance of reservoir conditions. Obviously, therefore, unanimous consent of operators and lessors is a practical necessity to make pressure control or secondary recovery feasible in any pool.

One of the many difficulties is that negotiations must be carried on in various stages. It is fundamental that all the operators be in accord before submitting a program to landowners. While there can be some preliminary discussion, usually the actual work of attempting to secure their consent cannot take place until the operators have eliminated their own differences of opinion and have actually executed the agreement.

Experience has shown that in most instances there are always a few holders of royalty interests who will not join. This raises complications as to whether an operating program can be carried out with relationship to those parcels of land which are not entirely committed to the Unitization Agreement; and if so, on what basis of royalty accounting. Thus, the feasibility of the entire project cannot be ultimately ascertained until the proportion of landowners and royalty owners who will consent to the agreement has actually been determined.

The reasons which lessors and royalty interests advance in refusing to consent to unitization are many and varied. Probably the most important one is that they simply do not understand the purposes of the agreement and the effect it will have upon them. It requires a great deal of educational work to overcome this hurdle. Another objection commonly encountered is that the engineering data and proposed method of operation indicate that a lessor will receive currently less royalty than he has been receiving under existing production practices. At the same time, the data may well indicate that in the long run he will receive a greater aggregate amount by joining the unit. Nevertheless, in many cases the amount of current royalty carries more weight with an individual than the total which may be obtained over the expected increased life of the field.

Then again, there is a type of lessor who has a fundamental objection to any sharing agreement with his neighbor. Usually, he thinks that his property is better than any other property in the pool. Sometimes he just does not like his neighbor. And this attitude, too often, applies to operators as well.

FEDERAL GOVERNMENT

Earlier I mentioned the fact that the Federal Government and some of the States as landowners have recognized the benefits of unitization. As a matter of fact, the Federal Government has recognized the desirability of unitization from a conservation standpoint, and has been active in securing necessary legislation to permit unitization of government lands. On the other hand, unfortunately, the government is often the most recalcitrant landowner when it comes to securing approval of a unitization project involving public lands. The "red tape" of securing departmental approval is formidable, but that is not all; the Federal Government is not content to stay in its position as a landowner. At this point I should like to make it clear that the following criticisms apply, not to field personnel, but particularly to the Washington Bureau of the Department.

Notwithstanding the good intentions and legitimate objectives of the operators in developing unit plans, the Department of Interior repeatedly attempts to include in unit plans such provisions as would require the owners of non-government lands and the operators thereof to subject such lands to Federal regulations applicable to public lands—not only those regulations in existence but any which may thereafter be adopted. It invariably attempts to repose in the Secretary of the Interior control over the extent of development and the rate of production of the unitized area. The attempts of the department to maintain the position of a lessor, and at the same time, and *at no risk*, to impose other controls by indirect means over all lands in the unit have caused untold loss by reason of delays and failures of projected plans. Because of these problems, there is often a natural reluctance within the industry to initiate a unit plan where government lands are involved. (See Note 1.)

FUTURE

A word to the future:

We are keenly aware of the tremendous importance of petroleum in the national—and world—economy. More recently, its attention focused by reason of seasonal shortages of essential products in critical areas, the general public is exhibiting a growing interest in and concern over this vital natural resource.

That interest and concern has been reflected in various inquiries and investigations by the Congress. The handwriting is on the wall. We in the industry are the entrepreneurs and primarily responsible for the diligent safeguarding and sensible exploitation of this most valuable commodity. To the ex-

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NOTE 1

As an indication that this may have been a severe criticism, I cite the following comment made following the original presentation of this paper by Mr. Jerry Powell, an attorney for the Union Oil Company.

"While in some instances unjustifiable delays have been encountered in completion of unitizations relating to producing fields with the Washington Federal authorities, we believe that criticisms of the Department of the Interior should not be too severe. During the last two or three years we have had numerous unitization matters in Washington concerning exploratory projects of large magnitude in the Rocky Mountain area and have been given prompt and efficient cooperation concerning which we could make no complaint. We were told in Washington that sometimes the operators present their matters too arbitrarily and do not make due allowance for the responsibility resting on Government officials at the present time with a possible change of administration impending and possibly a new Secretary of the Interior and partly new staff. A new appraisal of this situation may have to be made. One may, of course, at times encounter a typical bureaucrat who is himself arbitrary and not much inclined to cooperation, but we feel that generally and by and large if the question involved is approached with an understanding of the Government's responsibility in such matters as well as the results to be sought by the operators, and the Departmental men are handled with sufficient patience and tact, one's objectives may be reached without too much difficulty."

tent that we fail to prove competent or responsible, we are only inviting external interference.

This indisputable fact leaves us no alternative. We must, by one means or another, justify our stewardship.

As to the local scene:

In California I believe we are now at this stage of the game: On the one hand we can proceed voluntarily to continue to try to unitize those pools which are still susceptible to improved recoveries by such means. This means lengthy negotiations, consequent delays and varying degrees of effectiveness in many cases.

On the other hand, we may wish to utilize, if made available, State law which assures full play to voluntary arrangements but at the same time provides for regulatory action by the State with full and adequate protection guaranteed to both landowner and operator. (See Note 2.) Such unitization or secondary recovery statutes are law in several of the oil producing States. From information available throughout the industry, it appears that the Oklahoma Statute has recently been used in several instances with very satisfactory results. I fully recognize the controversial nature of this subject, but, with full respect for the other fellow's viewpoint sincerely offer the follow suggestions:

With protective features guaranteeing the rights of all parties-at-interest as a basis, I believe this much can be said for a unitization or secondary recovery statute: Unitization of a pool can be completed in a shorter period of time than has been our experience under voluntary negotiation, and projects can be made much more effective than has been the case thus far.

If the industry concludes that unitization by Statute, without arbitrary and unlimited powers being vested in a State agency, is appropriate, steps in this direction should be taken without delay. It is important not alone in connection with projects now in the stage of negotiation. It is more important in view of potential secondary recovery operations in the older and more depleted fields where properly selected means of stimulating production may still be used to good purpose.

If the industry concludes that unitization benefits may be sufficiently secured by voluntary negotiations alone, then I believe this approach should be implemented by an industry-sponsored educational program. Much can be done in telling the story of the basic principles and advantages of unitization. This should not be confined to the general public. It also is a story of great importance to operators, landowners, those who own royalty interests, lawyers and accountants.

Regardless of which route is taken, the industry must continue, and I believe it will continue of its own volition to extend and expand its efforts to assure the maximum ultimate recovery of oil and gas from our underground reserves by common action, utilizing, among other appropriate schemes, the principle of unitization with attendant pressure control or secondary recovery programs, or a combination of both, wherever possible. It is not only the part of wisdom, it is our duty, both to ourselves and to our country. ★ ★ ★

NOTE 2

It is interesting in this conection to note the recent recommendations made by the National Petroleum Council in its "Report on National Oil Policy", which was presented to the Secretary of the Interior on January 13th, 1949, among which are the following:

"Conservation of our petroleum resources will best be furthered by facilitating continued industry efforts to reduce waste and promote maximum recovery of oil through optimum-rate production, unit operation, secondary recovery and other methods."

* * * * * * * * *

"In oil fields in which more than one operator have interests, and where unit operation would result in greater ultimate recovery, appropriate action should be taken by the states to encourage such operations . . . where legal obstacles to such arrangements exists, the *state laws should be clarified to encourage voluntary co-operative unit plans.*" (Italics mine.)

CALIFORNIA POST-WAR PRODUCTION AND DEMAND

C. P. WATSON, MEMBER AIME, VICE PRESIDENT, SEABOARD OIL COMPANY, LOS ANGELES

In 1941, the California Oil Industry was producing an average of about 630,000 barrels daily. During the war, the California industry steadily increased its production until it reached an all time monthly production high in May, 1945, of 941,000 B/D (one day, in the summer of 1945, the production reached a peak of 980,000 B/D). This was a monthly increase slightly less than 50%. To do this, it was necessary to produce for a time, certain wells in excess of the M.E.R. — approximately 35,000 B/D. Also, it was necessary to drill new wells at Elk Hills, in the Naval Reserve, and increase that production above 7,000 B/D, the amount necessary to maintain conditioning of the wells, to 64,500 B/D—an increase of 57,500 B/D; also, to meet the military demand for the war, it was necessary to ship into California in 1945, by rail, a total of 12,000,000 barrels, and during 1945, withdraw 3,300,000 barrels from storage, bringing total storage down to 72,000,000 barrels. I might say in passing, that at the commencement of the war, total storage was at 140,000,000, and total withdrawals during the war of 68,000,000 barrels brought storage at the close of the war down to 72,000,000 —a storage supply considered to be as low as it should be.

We find California, at the close of the war in August, 1945, with a daily average production of approximately 941,000. The strain of extreme effort was eased immediately. Production in excess of M.E.R. was diminished. Elk Hills cut back to 7,000 B/D, a drop of 57,500 B/D. Shipments by rail from Texas ceased. And, in September 1945, we find the average production at 839,000, still 36% above the pre-war figure or 630,000 B/D.

The engineers and statisticians of the industry immediately set to work estimating the future requirements of the consumer public and military. Some came up with a figure close to the pre-war figure of 630,000 B/D; some predicted increases, larger or smaller.

But none, as far as I am able to ascertain, estimated the postwar peacetime demand of California to be *in excess* of the war time demand.

The factors which were expected to contribute to the increase *above* pre-war demand were as follows:

1. Continuing military demands.
2. Increased heavy industrial demand in manufacturing much needed durable and other items which were in short supply.
3. Increased domestic use because of migration of out-of-state people to California.
4. Increased gasoline use by "vacation starved" Californians.

The decline in production would probably have eased off still further in the fall of 1945, to a point below the September average of 839,000, had it not been for the immediate response of the public to peacetime opportunities, which caused the drop in production to be arrested at 839,000.

The four factors above referred to were duly considered and studied, but none anticipated or evaluated the astounding mass migration into California from states east of the Sierras. That mass migration of individuals and industries bids fair to continue for some years. California now has the greatest number of motor vehicles of any state in the Union, and the greatest number of such vehicles per capita. It is close to being the second state in the Union in gross population, and may achieve that rank very soon.

As factors 1, 2, 3 and 4 continued to function, the peace-time demand continued to increase. To meet that demand the state produced in 1946 an average of 862,000 B/D; in 1947, it produced an average of 913,000 B/S. And in 1948, to date, it has produced an average of 949,000 B/D (6 months) 4½% above the war-time peak and 14% above the production of September, 1945. The daily production now is over 951,000 B/D.

During the war the prices of crude oil and its products were frozen. Production was continued, and the products sold, at less than the cost of replacement. The oil industry (to use a well worn simile) took its stock off its shelves, and sold it at less than the cost of re-purchasing that stock. Moreover, during the war, by a short-sighted policy in high places, the supply of steel necessary to produce for a long war (if it had lasted a few months longer) was substantially forbidden to the oil industry, and unnecessary restrictions were "thought up" and applied. Notwithstanding this the oil industry produced and produced, and the armed forces were "oiled" and "powered" to victory.

So we are today producing for peacetime use 4½% above the war-time peak, with the demand probably aimed for a point far in excess of present production.

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How has this been done? How it is being done?

Not by new major discoveries of new reserves. Major discoveries are not found overnight, nor in a few short months. Such discoveries are found by long and painstaking effort; by deeper and deeper drilling; by use of heavier and heavier equipment; by development of new drilling techniques, and by development of new scientific means of locating structural features. Since 1939 there have been no discoveries of new major reserves. For some time, we have not even discovered new reserves adequate to replace the gross amount produced and consumed.

The demand has been set by reconditioning and cleaning out existing wells, especially old wells; by putting idle and formerly non-profitable wells on production; by drilling extensions of old fields, and extending production limits in old leases; by use of improved and expensive pumping equipment; by developing and using improved production techniques; and, by husbanding and aggregating such new reserve deposits as have been discovered.

From January 1, 1945, just before the close of the war, to January 1, 1948, the industry drilled 4,728 new producing wells, with a footage of 19,377,490; and deepened 434 old wells by an increased depth of 551,934 feet, besides reconditioning and cleaning out thousands of wells. Today we have over 25,000 wells producing, an increase of over 20% above pre-war figures.

The cumulative effect of field work since December, 1945, is expressed graphically on Plate 1 which combines the sources of production as between recompletions in old fields; new wells in old fields, and new discoveries. The magnitude of volume production from new wells in old fields—approximately 270,000 barrels per day—has not only cushioned, but partially offset, the estimated one percent per month decline of all fields. This is furthermore a direct expression of reserve increment due to economic factors.

It is also of interest to note the upward trend in increased volumes from new discoveries since December, 1945, with approximately 35,000 barrels daily

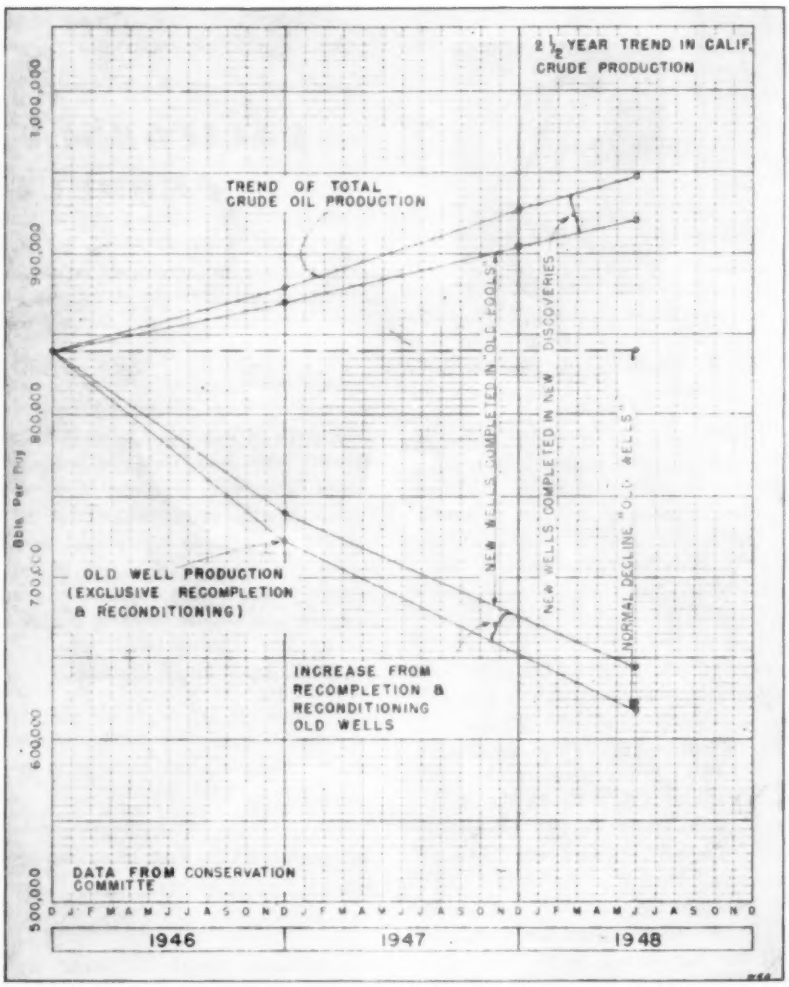

2 1/2 YEAR TREND IN CALIF. CRUDE PRODUCTION
TREND OF TOTAL CRUDE OIL PRODUCTION
NEW WELLS COMPLETED IN "OLD FOOLS"
NEW WELLS COMPLETED IN NEW DISCOVERIES
NORMAL DECLINE "OLD" WELLS
OLD WELL PRODUCTION (EXCLUSIVE RECOMPLETION & RECONDITIONING)
INCREASE FROM RECOMPLETION & RECONDITIONING OLD WELLS
DATA FROM CONSERVATION COMMITTE
Bbls. Per Day
1,000,000
900,000
800,000
700,000
600,000
500,000
D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D
1946
1947
1948

FIG. 1—TWO AND ONE-HALF YEAR TREND IN CALIFORNIA CRUDE PRODUCTION.

coming from this source in June, 1948. Admittedly, the volume is small, but the trend is significant.

These data — from December, 1945, to June, 1948 — provide a yardstick through which to measure the contribution that the Industry in California can make to stability in supply over the next five years.

It is the writer's belief that the Industry is capable of producing one million barrels per day of liquid petroleum for the next five years under favorable economic conditions, availability of adequate material and under "free enterprise." Beyond the five year period any estimate of available supply would be involved with too many uncertainties as to price, new discoveries, and volumes available from Elk Hills and Tide lands.

The courage and virility of free enterprise in the California Oil Industry continues unabated notwithstanding the drilling of 1,262 dry holes with a total footage of 5,455,268 feet during 1945-1946 and 1947.

Certain prophets of fear have been mournfully crying that we are "running out of oil." The remedy they propose is that they must now take charge. They call it "governmental control"—how they would produce more oil is not made clear.

Certain it is, that the catalyst which brings success in oil production is free private enterprise. That is the catalyst which brings together the know-how, the engineers, the geologists, management, and the capital to take the hazard and produce the oil. In government control there is not such a catalyst.★★

ALL INSTITUTE SECTION

APPEARING IN:
- MINING ENGINEERING
- JOURNAL OF METALS
- JOURNAL OF PETROLEUM TECHNOLOGY

Mineral Economics Division Established—Board Sets Preliminary Budget for 1949

At its meeting on Dec. 15, President Wrather presiding, the AIME Board of Directors recognized the newly organized Mineral Economics Division, established the preliminary budget for 1949 in new form, and decided to discontinue the Junior Foreign Affiliate grade of membership at the end of 1949 provided the necessary change in the bylaws is effected.

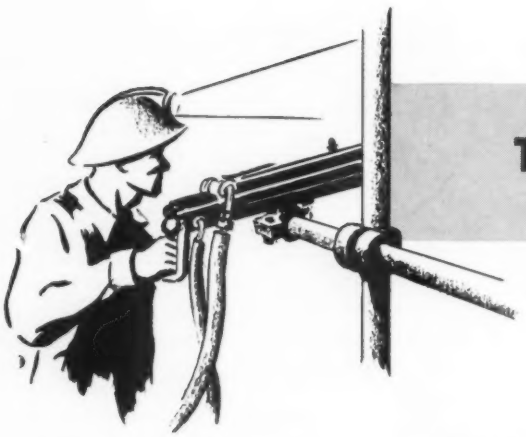
Richard J. Lund presented the petition for the establishment of the Mineral Economics Division. The President of the AIME is to appoint the initial officers, consisting of a Chairman, three Vice-Chairmen, and a Secretary-Treasurer. Ten committees are specified in the bylaws, as follows: National Security, Conservation, Tariffs and Subsidies, Taxation and Finance, Foreign Mineral Policy, Statistics, Transportation, Marketing, Mineral Use and Substitution, and Management and Public Relations. The purpose of the Division "shall be to stimulate interest and promote progress in broad economic and political aspects concerned with the search for, finding, developing, producing, transporting, refining, marketing, and use of metals and minerals of all kinds, including mineral fuels; to hold meetings for social intercourse and the reading and discussion of papers on mineral economics; to encourage and assist in arranging for the inclusion of meritorious papers and discussions on mineral economics on programs of Regional, Divisional, and Annual Meetings of the Institute; and to arrange for the preparation of suitable economic and political papers dealing with minerals, having broad coverage of the industry—domestic and worldwide—for publication and distribution by the Institute." No conflict was seen by the Board in the professed aims of the Division with the Institute's policy on controversial matters as adopted by the Board at its Feb. 21, 1933, meeting, and printed in the current Directory on page 85. It was suggested that the papers of this Division might be published in Section 2—the All-Institute Section—of the monthly journals unless they covered only the specific field of one of the Branches.

The preliminary budget for 1949 as presented to the Board by Mr. Daveler, chairman of the Finance Committee, was, for the first time, arranged according to Branches, in line with suggestions made by the Petroleum Division that such an allocation be made so that it would be evident which fields of Institute activity were showing a profit, if any, and which a loss. The proper ratio of membership between the three Branches cannot yet be fixed, as many members have not yet indicated their primary choice of a monthly journal for the coming year, but the Mining Branch was estimated to have 52 per cent of the membership, and the Metals and Petroleum Branches each 24 per cent. These ratios will be changed, when more returns are in, for the final budget to be adopted later. This preliminary budget showed, for the Petroleum Branch, income of $90,476 and expenses of $118,018; for the Metals Branch, income of $78,330 and expenses of $112,403; and for the Mining Branch, income of $220,443 and expenses of $194,771. The over-all income budgeted for the year is $369,250, and expenditures, $425,192, or a prospective deficit of some $56,000. Two new staff members were provided for in the budget—an assistant editor for the petroleum journal, and another man to serve the Mining Branch as editor or field secretary or both.

An interim auxiliary publications committee of the Extractive Metallurgy Division was approved as follows: Carleton C. Long, chairman, Hugh M. Shepard and John D. Sullivan. Also the following auxiliary publications committee for the Petroleum Division was approved: Gordon H. Fisher, chairman; Owen F. Thornton, vice-chairman; J. Daviss Collett, K. C. Howard, Paschal Martin, and J. A. Slicker.

Appointments of AIME representatives on various committees and organizations were made as follows: Council of the American Association for the Advancement of Science, C. H. Mathewson and Donald H. McLaughlin; Seeley W. Mudd Memorial Fund, Wilber Judson; Engineering Societies Monographs, Reed W. Hyde; Engineering Index, Landon F. Strobel; Mining Standardization, ASA, Benjamin F. Tillson and Robert H. Morris; Pressure Piping, ASA, R. E. Crockett and Clarence M. Haight; American Year Book Corp., Bradley Stoughton.

Michael Tenenbaum was reported as having been selected to receive the Robert W. Raymond Memorial Award at the Annual Meeting.



THE DRIFT OF THINGS

. . . as followed by EDWARD H. ROBIE

Mining's Biggest Year

Mineral production in the United States reached an all-time peak again in 1948, according to data released at the end of the year by the Bureau of Mines. The tonnage of mineral fuels produced increased 4.8 per cent over 1947, other nonmetallic minerals 4.7 per cent, and metals 2.9 per cent. Expressed in value of output the figures were even more striking, of course, because of inflation, the total value of the mineral output being 15.6 billion dollars compared with 12.4 billion in 1947, an increase of 26 per cent.

The iron and steel industry operated at near-peak levels during most of the year and registered a 3½ per cent gain in output, at 88,000,000 tons of ingots and castings, but still this was only the third best year in the history of the steel industry. Strikes held back copper, lead, and zinc production so that output for the year was below that of 1947 by 1, 6, and 4 per cent respectively. Aluminum production achieved a new peacetime high but was a third below 1944. Gold output fell off 5 to 10 per cent because of higher costs and a fixed price for the product but the 90½-cent price of silver for the full year raised output of that metal by 5 per cent. Mercury production dropped sharply—to 13,950 flasks—because of imports at low prices, and at the end of the year only two companies were still operating.

Crude oil production gained 8 per cent, exceeding 2,000,000,000 barrels for the first time, at an average price of $2.59 per barrel. Ten per cent more natural gas was marketed. Bituminous coal and lignite output, at 596,000,000 tons, was down 5 per cent from the 1947 record because of a strike in March and April and reduced demand in the latter half of the year. Soft coal averaged $4.87 a ton at the mine. Anthracite, 57,000,000 tons, was about the same as in 1947, worth about $8 a ton.

Among the nonmetallics, all-time record shipments were made of sulphur, lime, salt, phosphate rock, potash, cement, gypsum, stone, kaolin, barite, talc, boron minerals, and vermiculite.

Many nonferrous metal mines, though enjoying high prices for their product, were prevented from setting new records in production during 1948, owing to strikes and a continued shortage of underground labor, but the Lake Superior iron mines, highly mechanized, were more fortunate. Vessel shipments down the Great Lakes totaled 82,937,291 long tons of ore (moisture included). This is a record for peacetime, and not greatly below the all-time high of 92,076,781 long tons reached in 1942. If high-grade iron ore reserves of the Lake Superior region are rapidly nearing exhaustion, that fact apparently has not yet acted as a brake on output.

Our Growing Institute

Along with its monthly bills, the telephone company sends little pamphlets concerning its service, and we are tempted to paraphrase the latest of these we have received, making it apply to the service the Institute gives:

There are lots of "hidden values" in your AIME service that can't be measured entirely in dollars and cents. There's the prestige of being a recognized member of your professional fraternity, the privilege of attending its meetings, of writing papers for its publications, or working with others on its committees. All these hidden values grow every time a new member is added to the roster. For it's pretty obvious that the more people that you can thus associate with, and who can associate with you, the more your membership is worth. So you'll be interested to know that, in the last fourteen years, more than 8000 members, net, have been added to the rolls, an increase of 118 per cent.

A New Commercial Metal?

Most of the metals commonly used were known and used hundreds, and some thousands, of years ago; a few, like aluminum, magnesium, and nickel, have achieved commercial importance only in the last 50 or 75 years. Is titanium destined to be the latest addition to the list of new and important metals?

The question is suggested by the expected early development of an immense body of titanium ore in Quebec, and of the good possibility that other deposits may be found, for the metal is supposed to be the seventh most common one in the earth's crust. Since the recent development of another large ore body in the Adirondack Mountains of New York State, titanium has been chiefly used in the oxide form as a white pigment, usually combined with zinc and lead in paint. It has also been on the market as ferrotitanium, but its use as a pure metal has been rare. The first such application that we can remember was as a filament in incandescent lamp

bulbs, a few such lamps being used about the time the carbon filaments were going out and the tungsten lamps coming into use.

The du Pont Company now has a pilot plant in operation with a capacity of 500 lb of titanium metal per day. The price is said to be $5 per pound, which would be excessive if the metal were made according to well-known production processes, but it is entirely within the realm of possibility that this figure could be shaded considerably if a new or improved process were developed, and commercial production on a large scale were carried on. Aluminum once sold for some such fancy price. Strength and corrosion resistance of titanium are comparable with stainless steel, under some conditions, at half the weight. It is less than twice as heavy as aluminum, but is about forty per cent stronger. It has a high melting point, and may find use in jet power plants and in the development of atomic power. A whole new family of titanium alloys is predicted.

News from Europe

Excerpts from a letter dated Nov. 16 from a friend who recently attended the Geological Congress in England, and has since traveled across the Continent to Italy:

Since arriving in Italy six weeks ago we have moved several times and I assure you that house-hunting in the smaller towns of this country is a bit of a problem though we've found fairly comfortable accommodations so far. We've been amazed at the recovery Italy has made. Factories are working and the railroads and highways carry a constant stream of freight. Out in the country the fields are teeming with people and everyone looks well. Some of the larger cities are a bit rugged, and there one sees some underfed and poorly clothed people. Food is plentiful and good although the Continental breakfast of coffee and a piece of bread makes us dream about hot cakes, bacon and eggs, etc. The highways are remarkably good, and a network of excellent secondary roads spreads out from the main trunk lines. However, don't take too much stock in all you hear about "sunny Italy." We're about to freeze to death most of the time, especially when we sit in an unheated room and look towards the snow-capped Apennines. All in all, Italy has been a pleasant surprise, but we'll be plenty ready to start home.

After the Geological Congress in London we took the two weeks' excursion to the Scottish Highlands. Up there we tried to keep up with Sir Edward Bailey, 67 years old, a rugged Scotch geologist who has spent his life in the Highlands and thinks nothing of taking a dip every frosty morning in the nearest loch. We managed to stay alive by huddling in wool shirts and raincoats. Stern, rocky mountains wreathed in almost perpetual mist, and pounded by howling gales with stinging rain thrown in your face while you climb 3000 ft to see some of the world's most complex geology—that's our impression of Scotland. And through all this stalked Sir Edward Bailey, bald head streaming with raindrops just about freezing, and clad only in shorts and a coat. It made me realize what fifteen years in the tropics does to your blood.

From England we crossed over to France, but only passed through. Had two weeks in Switzerland—our favorite of them all in every respect—food, people, and geology. From Zurich we drove through the Gothard Pass and so to Italy.

Let's Be Fair

That excellent weekly covering the Canadian mining industry, *The Northern Miner*, publishes the following editorial, based on ours in the December M&M:

Publications Should Stand On Own Feet

"Admission that the publication of *Mining and Metallurgy* has cost the AIME an average loss of $7,100 a year from 1920 to 1947 is made in announcing a reshuffle of the American institute's publications. The announcement confesses that the magazine when it sought greater advertising support met with opposition from the *Engineering and Mining Journal*. Now it is on the friendliest of terms with others papers in the mineral field, so it says, and adds that magazine publishing by professional societies has become 'generally accepted.'

"It is to be doubted whether such competition is truly accepted, except out of politeness. Mining journals that must appeal for subscriptions and advertising on their intrinsic usefulness to the public are able to assist the growth of their industry. The kind of competition which can afford large annual losses takes from commercial journals revenue which could be applied to enlarging the field of employment and advancement of professional men."

The writer of the above makes no mention of the fact, as plainly stated in the editorial on which he comments, that the average annual "loss" of $7,100 on M&M was incurred without any credit for subscription fees from members. If something like one dollar per year were allowed for a subscription fee, the magazine would have about broken even, and at the $1.50 rate nominally allowed for members' subscription fee to M&M through most of its history, a substantial profit would have been made. We wonder if *The Northern Miner* and other publications in the mining field would not also show a "loss" if they received no income from subscriptions.

Also, the implication is made in the above editorial comment that the publications of the AIME are not intrinsically useful and do not assist the growth of the industry they serve; that only "commercial" journals "enlarge the field of employment and advancement of professional men." We simply do not think this is so. We believe both professional society and privately published papers and magazines promote the advancement and the good of the professional men and the companies engaged in the industries they serve. One difference is that in the case of the professional societies no outside stockholders get any part of the profits that may be derived from such service. Certainly a part of the increased profit that private publications would make if they had no competition from society publications would go to their stockholders, whereas all the income received by the publications of the professional societies is a credit against their cost of operation, either acting as a brake on increases of dues, or making it possible for the members to get more for their money.

RICHARD J. ENNIS

Director, AIME

With but two geographical hops and one professional stint, Richard J. Ennis landed in the Porcupine district of Ontario. And although he remained stationary after this seven-league-boot sprint of 38 years ago, he managed to build up an éclat that has spread his name round the world. This feat of repose was accomplished at his Schumacher retreat by doing the work of the vice-president and general manager of McIntyre Porcupine Mines, Ltd.; of a councillor, vice-president, and president, successively, of the Canadian Institute of Mining and Metallurgy; and of a leader in the research that led to a preventive of silicosis.

It all started in Sheffield, Ill., where he was born in 1881. The next stop was the Smuggler Mining Co. of Aspen, Colo., to spend six years learning, at first hand, the art of the miner and millman. Then, a lord in the industry of those days who was duly impressed by Mr. Ennis's show of competence and enthusiasm invited the self-made man to design, erect, and operate a ten-stamp mill for a prospect in the Porcupine wilderness. With his acceptance, in 1911, came the development of what today is recognized as McIntyre Porcupine Mines, Ltd.

The story that fills the intervening years is marked by Mr. Ennis's own personality. Under his leadership the company sank twelve shafts—one to a depth of 7025 ft; built a 2450-ton flotation and cyanidation plant; and established McIntyre Research, Ltd., through which aluminum therapy was developed as a silicosis preventive.

A more precise appraisal of Mr. Ennis would be that offered by an old colleague:

"Starting out on his own in early life, he has, through constant study and successful experience, acquired an extraordinary knowledge of all things pertaining to the mining industry. He can hold forth with authority on what are the essential characteristics of a good mine hoist, the proper way to plan a stope or float gold, and, in the same tempo, switch into a description of a human lung—how fine silica particles attack it and how aluminum dust prevents the formation of silicic acid, and thus, with the elimination of dust so far as is possible and the use of the aluminum powder, how silicosis may be controlled and probably eliminated.

"In character, he is the happy, buoyant, friendly type of man—the perfect host. He is the typical leader, with great vision and the courage and energy to evolve new methods and then follow them through to a successful conclusion. I would say he is an out-and-out Irishman with almost all the characteristics peculiar to one of that race, and which include, in addition to those above described, the qualities of modesty and warm sympathy for those in trouble or distress."—*H.K.*

Malcolm Pirnie Receives Hoover Medal

Malcolm Pirnie, consulting engineer and head of the firm of Malcolm Pirnie Engineers, New York, has been named 1948 winner of the Hoover Medal, jointly awarded by four national engineering societies, Scott Turner, chairman of the Hoover Medal Board of Award, has announced. The award, one of the outstanding honors of the engineering profession, is in special recognition of Mr. Pirnie's leadership in the formulation of a program, sponsored by the Engineers Joint Council, for the postwar industrial control of Germany and Japan.

The medal was conferred at the Hotel Commodore, New York, on Jan. 19, the opening day of the 96th annual meeting of the American Society of Civil Engineers, of which Mr. Pirnie is a past president. The citation read: Malcolm Pirnie, engineer, leader of engineers and servant of his fellow man, whose ideals and accomplishments in public life beyond the call of his profession have benefited men in his own and other countries of the world, is awarded by his fellow engineers the Hoover Medal for 1948.

The program for the industrial disarmament of the aggressor nations, in which Mr. Pirnie played a leading part, was a voluntary contribution of the engineering profession toward world peace. It was carried on by the EJC through its National Engineers Committee, with Mr. Pirnie as chairman. Five national engineering societies are represented on this council.

The program for Germany got under way in 1944. It stated one clear objective: "an effective industrial means to keep Germany from starting another war." Removal of the plant and source materials essential to war was advocated but "with the least disturbance to the normal economy of western Europe." The program opposed "any plan which would make postwar Germany a drag on the economy of all Europe, if not of the world, and a breeder of future wars."

Later a similar report was prepared on the industrial disarmament of Japan. These reports, with their factual and scientific approach to the world recovery program, were approved in principle and in their main essentials by the State Department and Allied Control Council.

Winners of Student Paper Contests Announced

A telegram has just reached us before we go to press from C. B. Carpenter, chairman of the Student Prize Paper Contest Committee, announcing the winners of the 1949 contest. Winning first place in the graduate paper contest is W. E. Ellis, University of Illinois, and second place goes to F. J. Radavich, Purdue University. Winners in the undergraduate contest are: D. W. Pettigrew, Jr., Carnegie Institute of Technology; J. B. Seabrook, MIT; and G. T. Horne, Montana School of Mines. All were invited to receive their awards at the Annual Meeting in San Francisco.

First Pan-American Engineering Congress Planned

In an effort to establish closer relations between engineers in the Americas for their mutual benefit, the South American Union of Engineering Associations has decided to hold, in co-operation with engineering associations throughout the Americas, the First Pan-American Engineering Congress, from July 15 to 24, 1949, in Rio de Janeiro. Members of the AIME are cordially invited to participate by presentation of papers and attendance.

Of particular interest to members of the AIME will be sessions on fuel, mining engineering, geology, and metallurgy. Papers must be submitted by April 30. Copies of the agenda may be obtained from the Engineers Joint Council, 29 West 39th St., New York 18.

Calendar of Coming Meetings

FEBRUARY

1 **Society for Applied Spectroscopy, 63 Park Row, New York City, 8 p.m. F. Nolan, on fluorescence.**
2 **Chicago Section, AIME. S. J. Creswell, on the Bessemer process.**
3 **Reno Branch, Nevada Section, AIME.**
4 **Columbia Section, AIME.**
7 **Boston Section, AIME.**
8 **East Texas Section, AIME.**
9 **El Paso Metals Section, AIME.**
11-12 Association of American State Geologists, San Francisco.
11-12 New Mexico Miners and Prospectors Assn., Santa Fe.
14 **Mid-Continent Section, AIME.**
14-17 **Annual meeting, AIME, Fairmont Hotel, San Francisco.**
15 **Gulf Coast Section, AIME.**
15 **Washington, D. C., Section, AIME.**
16 **Southwest Texas Section, AIME.**
17 **Carlsbad Potash Section, AIME.**
17 **North Pacific Section, AIME.**
17 **Utah Section, AIME.**
18 **Oregon Section, AIME.**
21 **Detroit Section, AIME. C. Lipson, on stress analysis.**
22 **Montana Section, AIME.**
28 **Alaska Section, AIME.**
Feb. 28-Mar. 4 ASTM, spring meeting and committee week, Hotel Edgewater Beach, Chicago.

MARCH

2 **Chicago Section, AIME. J. R. Van Pelt, Jr., on mineral economics.**
3 **Reno Branch, Nevada Section, AIME.**
3-5 Symposium on Southeast mineral resources, University of Tennessee, Knoxville.
4 **Columbia Section, AIME.**
7 **Boston Section, AIME.**
8 **East Texas Section, AIME.**
9 **El Paso Metals Section, AIME.**
9 **San Francisco Section, AIME.**
10-12 American Physical Society, Division of Solid State Physics, annual meeting, Hollenden Hotel, Cleveland.
14 **Mid-Continent Section, AIME.**
14-17 American Association of Petroleum Geologists, annual meeting, Hotel Jefferson, St. Louis.
15 **Gulf Coast Section, AIME.**
15 **Washington, D. C., Section, AIME.**
16 **Southwest Texas Section, AIME.**
17 **Carlsbad Potash Section, AIME.**
17 **North Pacific Section, AIME.**
17 **Utah Section, AIME.**
18 **Oregon Section, AIME.**
21 **Detroit Section, AIME. R. K. Hopkins, on the Kellogg process.**
22 **Montana Section, AIME.**
28 **Alaska Section, AIME.**
Mar. 29-Apr. 1 Annual Safety Convention and Exposition, Hotel Statler (Pennsylvania), New York City.

APRIL

5-6 Metal Powder Assn., 5th annual meeting and exhibit, Drake Hotel, Chicago.
11-14 National Assn. of Corrosion Engineers, 5th Annual Conference and Exhibition, Netherland-Plaza, Cincinnati.
18-20 Midwest Power Conference, Sherman Hotel, Chicago.
18-20 **Open Hearth Conference, and Blast Furnace, Coke Oven and Raw Materials Conference, Palmer House, Chicago.**
24-28 American Ceramic Society, national meeting, Netherland-Plaza, Cincinnati, Ohio.

MAY

2-5 American Foundrymen's Society, 53rd annual meeting, St. Louis.

SEPTEMBER

25-28 **Regional Meeting, AIME, Neil House, Columbus, Ohio.**

OCTOBER

17-19 **Institute of Metals Division, AIME, fall meeting, Cleveland.**

DECEMBER

8-10 **Seventh Annual Conference, Electric Furnace Steel Committee, Iron and Steel Division, AIME, Hotel William Penn, Pittsburgh.**

FEBRUARY 1950

12-16 **Annual Meeting, AIME, Statler (Pennsylvania) Hotel, New York City.**

APRIL 1950

10-12 **Open Hearth Conference, and Blast Furnace, Coke Oven and Raw Materials Conference, Netherland-Plaza Hotel, Cincinnati.**

DECEMBER 1950

7-9 **Eighth Annual Conference, Electric Furnace Steel Committee, Iron and Steel Division, AIME, Hotel William Penn, Pittsburgh.**

What Went on at Recent Local Section Meetings

SECTION	DATE	PLACE	PRESIDING OFFICER	ATTEND-ANCE	SPEAKER, AFFILIATION, AND SUBJECT
Arizona	Oct. 20	Pioneer Hotel, Tucson		23	W. E. Wrather, President, AIME. Institute Affairs.
Black Hills	Dec. 9	South Dakota School o Mines, Rapid City			Business meeting.
Boston	Dec. 6	Metals Processing Laboratory, MIT	George P. Swift	55	Howard F. Taylor, associate professor of mechanical engineering, MIT. Renaissance of the foundry.
Carlsbad Potash	Dec. 14	Riverside Country Club	R. H. Allport	120	Social meeting.
Colorado	Dec. 17	University Club, Denver	M. I. Signer	57	Steve Arrick, Le Panto Consolidated Copper Co. Present conditions in the Philippines.
Columbia	Oct. 1	Spokane	J. W. Melrose	15	Field trip to Trentwood aluminum rolling mill Permanente Metals Corp.
Columbia	Nov. 5	Spokane	Harold Culver	20	Film, "An Ore Sample," American Cyanamid Co.
Delta	Dec. 7	Petroleum Club, New Orleans	J. C. Posgate	50	L. V. McConnell, Lane Wells Co. Engineering of well depth measurements.
Detroit	Nov. 22	Detroit	C.L. Raynor	100	F. N. Rhines. associate professor of metallurgy, Carnegie Institute of Technology. Sintering of metal powders.
El Paso Metals	Dec. 8	El Paso			L. J. Russel, Paul E. Ayers, and M. E. Alarcon USNR, El Paso district. U. S. Navy in World War II.
El Paso Metals	Dec. 17	Biltmore Hotel, El Paso		70	Social meeting with Woman's Auxiliary.
Lehigh Valley	Dec. 6	Bethlehem	M. L. Fuller	125	W. E. Wrather, President, AIME. Recent trip to the Near East.
Mid-Continent	Dec. 13	Tulsa	John P. Hammond	117	P. P. Scott, Jr., Stanolind Oil and Gas Co. Factors to be considered in obtaining proper cementing of casing.
Montana	Dec. 8	Finlen Hotel, Butte	H. G. Satterthwaite	92	Business meeting.
North Pacific	Dec. 16	Rose's Highway Inn, Seattle		60	E. N. Patty, president, Alluvial Gold, Inc. Placer prospecting as an aid to lode discovery.
Tri-State	Dec. 1	Tri-State Zinc and Lead Ore Producers Assn., Picher	O. W. Bilharz	6	Business meeting.
Tri-State	Dec. 8	Picher	O. W. Bilharz	55	Jack Pulliam, Allis-Chalmers Mfg. Co. Atomic bomb test at Bikini.
Wyoming	Dec. 11	Park Hotel, Rock Springs	H. C. Livingston	20	M. M. Fidlar, chief geologist, Mountain Fuel Supply Co. Church Buttes gas field.

New Local Section Officers

ALASKA SECTION . . .

Ted C. Mathews, Chairman; Patrick H. O'Neill, Vice-Chairman; Ralph B. Norris, Secretary-Treasurer; Leonard M. Berlin, Vice-Chairman for Juneau; Harold Strandberg, Vice-Chairman for Anchorage; Frank E. Love, Vice-Chairman for Nome.

BLACK HILLS SECTION . . .

Fremont Clarke, Chairman; Paul Gries, First Vice-Chairman; J. O. Harder, Second Vice-Chairman; A. L. Slaughter, Secretary-Treasurer; Renaldo Gallo, A. B. Needham, and Albro Ayres, Executive Committee.

CARLSBAD POTASH SECTION . . .

J. P. Smith, Chairman; G. E. Atwood, First Vice-Chairman; E. W. Douglass, Second Vice-Chairman; John Nutt, Secretary-Treasurer.

COLORADO SECTION . . .

M. I. Signer, Chairman; J. W. Vanderwilt, Vice-Chairman; J. Paul Harrison, Secretary-Treasurer; E. D. Dickerman, C. E. Dobbin, M. H. Robineau, E. J. Eisenach (Climax Subsection), and H. S. Worcester (San Juan Subsection), Directors.

DELTA SECTION . . .

E. N. Dunlap, Chairman; H. M. Krause, Jr., and C. R. Blomberg, Vice-Chairmen; Fred E. Simmons, Secretary-Treasurer; Paul Ratliff, Junior Secretary; B. C. Craft and H. C. Petersen, Directors.

LEHIGH VALLEY SECTION . . .

F. E. VanVoris, Chairman; R. T. Gallagher, B. J. Larpenteur, and Robert B. Hoy, Vice-Chairmen; W. S. Cumings, James Guider, and M. L. Fuller, Managers.

MONTANA SECTION . . .

J. Hollis McCrea, Chairman; J. P. Spielman, Vice-Chairman; F. W. Strandberg, Secretary-Treasurer; Kuno Doerr, Jr., and E. C. Van Blarcom, Executive Committee.

NORTH PACIFIC SECTION . . .

Kenneth H. Anderson, Chairman; L. W. Heinzinger, Vice-Chairman; W. C. Leonard, Secretary-Treasurer.

TRI-STATE SECTION . . .

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UTAH SECTION . . .

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News of AIME Members

Oliver Bowles

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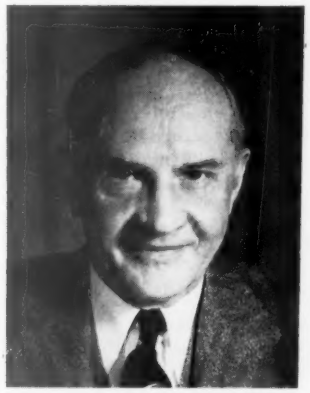
John Van Nostrand Dorr



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Elmer R. Ramsey

Oliver Bowles was presented with the Gold Medal of the Department of the Interior on Dec. 15. The citation for distinguished service upon completion of 33 years of continuous service with the Federal Government reads: During his 33 years with the Bureau of Mines, he strongly influenced the growth of its work in the technology and economics of nonmetallic minerals. Author of more than 250 publications, 153 of them official publications of the Bureau, covering the broad field of nonmetallic minerals, and of a standard textbook, "The Stone Industries," he won international recognition as an authority on mining and quarrying. By introducing the wire saw, he enabled the American slate industry to expedite production, reduce waste, and cut costs. During the war, his opinion and advice on many problems involving nonmetallic minerals were eagerly sought by and freely given to the Government's war agencies. From 1914, when he became the Bureau's first quarry technologist, to Jan. 31, 1947, when he retired as chief of the nonmetallic minerals economics branch, Dr. Bowles served the nation with zeal, integrity, and distinction that entitle him to the highest commendation of this Department.—*J. A. Krug, Secretary of the Interior.*

John Van Nostrand Dorr, chemical, metallurgical, and industrial engineer, prolific inventor and founder of The Dorr Co., New York City, and five associated companies in Europe, has been elected to the newly created office of chairman of the board. **Elmer R. Ramsey,** who has been connected with the Company for 34 years, filling various positions, and more recently operating vice-president, became president. These changes became effective Jan. 20. He continues as chairman of the board of directors of Dorr-Oliver Co., London.

The Dorr Co. was started some forty years ago, literally as a 'one-man' organization, to apply a succession of inventions made by Dr. Dorr in plant operation in the Black Hills of South Dakota. The rest of the story is familiar—the 'one-man' organization gradually becoming an expanding engineering group. The Company's new inventions and new applications of the old carried it from its original metallurgical field through sugar and sanitary engineering and into the chemical industries and geographically pretty well around the globe. The present step in the development of its management is another step in the company's expansion and development.

Dr. Dorr's life has been one of engineering alertness, prolific inventiveness, and originality, in not one field but many, leading to industrial success, as well as full professional and academic recognition for his many and varied technical achievements. His own 26 inventions, notably the Dorr classifier, Dorr thickener, and Dorr agitator and modifications thereof, plus those of his staff, have been applied successfully in over a hundred separate and distinct processing industries. They have made it possible to convert intermittent chemical processes to continuous ones; they have contributed to the large-scale, low-cost exploitation of low-grade ore deposits; they have contributed to placing municipal and industrial sewage and water treatment on a sound engineering basis, to the benefit of the public health at home and abroad.

Mr. Ramsey became associated with Dr. Dorr in 1913, soon after graduation from the Colorado School of Mines. He started on design and test work in the Black Hills, and then took the job of junior engineer at the Denver plant. By 1927 he was in New York, where he became, consecutively, assistant general sales manager, executive assistant to the president, vice-president in charge of engineering department, operating vice-president, and now president.

Howard O. Gray resigned as mining editor of the *Joplin Globe* and *News Herald* and as secretary of the Tri-State Zinc and Lead Ore Producers Assn. on Dec. 1. He plans to engage in private business.

Robert B. Hall, geologist with the U. S. Geological Survey, has been transferred from Spread Eagle, Wis., to Grand Junction, Colo., P. O. Box 337.

R. J. Horsman is chief engineer for Day Mines Inc., Wallace, Idaho. His mail address there is 305 3rd St.

Donald C. Howe, former field supervisor for the Cardox Corp., has been made assistant mine foreman of the Vesta coal division of the Jones and Laughlin Steel Corp., California, Pa.

Carlton D. Hulin visited Institute headquarters during December while in New York on business for the Tungsten Mining Corp. for whom he is consulting geologist.

Danforth Jackson has a job in the geology department of the Republic Steel Corp., Port Henry, N. Y.

L. R. Jackson, who has been general manager of Ariston Gold Mines (1921) Ltd., is chairman and general manager of the Cyprus Sulphur and Copper Co., Limni Mines, Polis, Cyprus; the Company is engaged in reopening a mine formerly worked by the Phoenicians and Romans for copper.

William Karsten is mine shift boss for Cia. Huanchaca de Bolivia, Pulacayo, Bolivia.

Harry W. Kemery is assistant to the superintendent of the Tamaqua district of the Lehigh Navigation Coal Co., Lansford, Pa.

M. H. Kline for the past three years has been working with the Bureau of Mines. He is chief of the special minerals investigation branch at Mt. Weather, Bluemont, Va.

Simon Lake, III, has returned from Felton, Oriente, Cuba, where he was with the Juragua Iron Co., and can be reached at 1313 Fairmont Ave., Fairmont, W. Va.

T. F. Maddick, formerly with the St. Joseph Lead Co., is now employed by the Anaconda Copper Co., Butte, Mont., in the mechanical engineering department.

Samuel A. Madrid is vice-president and manager of the Hamilton Equipment Co., 257 Rio Grande St., Salt Lake City. He was with the Smith Engineering Works in Milwaukee.

Burt C. Mariacher, who was addressed in care of the Consolidated Feldspar Corp., Parkdale, Colo., is now reached in care of the Western-Knapp Engineering Co., 50 Church St., New York City 7.

Ernest N. Patty

Ernest N. Patty, president and general manager of Alluvial Golds Inc. and Gold Placers Inc., returned to his Seattle office last fall after spending the summer in Alaska and the Yukon Territory supervising gold dredging operations there.

Elmer Isern

Elmer Isern, who has been active in mining operations in the Tri-State district for more than twenty years, has been elected president of the Eagle-Picher Mining and Smelting Co., a subsidiary of the Eagle-Picher Co. Mr. Isern, a native of Ellinwood, Kans., and a graduate of Kansas University, worked for several years in Montana and California before going to Miami, Okla., as metallurgist and general milling superintendent for the Commerce Mining and Royalty Co. In 1939 he joined Eagle-Picher as metallurgist and general milling superintendent.

George P. Lutjen joined the staff of the *E&MJ* as assistant editor on Feb. 1. He had been a mining engineer for the Freeport Sulphur Co. since 1943 except for two years which he served with the Marine Corps in China. Mr. Lutjen is a graduate of the Columbia School of Mines.

H. Eugene Mauck recently accepted the post of assistant to the president of the Olga Coal Co. He was formerly superintendent of the Westland mine of the Pittsburgh Coal Co. His headquarters are in Cleveland in the Union Commerce Bldg. and his work takes him to the operations in southern West Virginia. There are three mines operating near Welsh, two of which mine the Pocahontas No. 4 seam and one of which mines the War Creek of Beckley seam with a total annual production of about 2,500,000 tons. Upon graduation from Penn State in 1939, Mr. Mauck entered a training program with the Pittsburgh Coal Co. He served as mine superintendent for that company for about six years.

John D. McAuliffe has been made mine superintendent of Falconbridge Nickel Mines, Ltd., Falconbridge, Ont.

Francis J. McCavitt, formerly a student at the New Mexico School of Mines, is chief of party of a U. S. Geological Survey topographic branch, Box 2858, Lakewood, Colo.

Vernon L. McCutchan, formerly assistant general manager of the Cerro de Pasco Copper Corp., Oroya, Peru, is now addressed at 140 5th St. W., Dickinson, N. Dak.

A. R. McGuire is president of the Fresno Mining Co., 415 Brix Bldg., Fresno, Calif., which operates the Strawberry tungsten mine.

A. L. Minter has taken a job as chemical engineer for the Loceria Colombiana, Medellin, Colombia, and is also engaged in mining consulting work.

Harry W. Montz left for Shanghai, China, on Dec. 8 as a representative of the J. G. White Engineering Corp. in connection with development of China's resources. He expects to be gone from one to one and a half years.

William P. Morris is research engineer at the research laboratory of the Oliver Iron Mining Co., 4832 Grand Ave., Duluth 7, Minn.

Garrett A. Muilenburg, who has been professor of geology at the Missouri School of Mines, has joined the staff of the Missouri Geological Survey, Rolla.

Randall T. Murrill, who has been local superintendent for the Mine La Motte Corp., is now general mine superintendent for the St. Joseph Lead Co., Bonne Terre, Mo.

Kenneth W. Nickerson, Jr., after graduation from the Colorado School of Mines last July and a short vacation at his home in Riverside, Calif., reported to work as a geologist for the Kennecott Copper Corp., Ray mines division, Hayden, Ariz.

Edward S. O'Connor is vice-president of the Hi-Heat Coal Co., 1894 E. 39th St., Salt Lake City. He had been with the Columbia Steel Co.

W. T. Pettijohn resigned as mine superintendent with the Mufulira Copper Mines Ltd., Mufulira, N. Rhodesia, in September and returned to the States to take up employment with the New Jersey Zinc Co. at Austinville, Va.

Colwell A. Pierce has retired as general superintendent of the U. S. Potash Co., Carlsbad, N. Mex. **Henry H. Bruhn,** former refinery superintendent, has been made resident manager with general supervision of mining and refinery operations.

Leslie W. Pullen, who was with the Oliver Iron Mining Co., has gone to Holden, W. Va., to join the engineering department of the Island Creek Coal Co.

Mat Sample, who has been in Chuquicamata, Chile, with the Chile Exploration Co., can now be reached at East Moriches, L. I., N. Y.

Robert M. Shapiro is an instructor at Penn State Extension University, Dravosburg, Pa., and also a graduate student at the University of Pittsburgh. His address is 434 S. Graham St., Pittsburgh.

William Sharp has changed his address from Eureka, Nev., to 1073 E. 6th S St., Salt Lake City.

Paul L. Shields has resigned as president of the Sheridan-Wyoming Coal Co. and has accepted the presidency of three Utah coal companies, Spring Canyon Coal Co., Royal Coal Co., and Standard Coal, Inc. **Walter J. Johnson,** general superintendent of the Bell & Zoller Coal and Mining Co., succeeds Mr. Shields as president of Sheridan-Wyoming.

John F. Simpson, Jr., after graduation from Penn State, became employed by the Clearfield Bituminous Coal Corp. at Arcadia, Pa. His present address is 28 Herman St., Commodore, Pa.

J. D. Sperr has been made construction inspector for the City of Oakland, Calif. His address there is 3600 Victor Ave., Oakland 19.

Charles E. Stott, who was vice-president and general manager of Cia. Minera de Penoles, division of the American Metal Co., is engaged in consulting work in Monterrey, Mexico.

Guy C. Riddell

Guy C. Riddell returned to the States in October after a year in Korea where he acted as mining advisor to the National Economic Board, Military Government, and Korean Government. He is staying at his farm at Royal Oak, Md.

William D. Lord, Jr.

William D. Lord, Jr., is now mine superintendent for the International Mining Co., an enterprise of W. R. Grace & Co. of New York City, at its Chojilla mines.

Roy G. Stott has been transferred by the Bureau of Mines from the Duluth office to its district offices at Wilkes-Barre, Pa., in the anthracite coal mining area.

Lester S. Thompson returned several months ago from Germany, where he had been conducting special studies for the Department of the Army.

Thaddeus S. Ullmann is assistant manager of the export department of the Eimco Corp., manufacturers of mining equipment, New York and Salt Lake City. His home address is 68-49 Burns St., Forest Hills, N. Y.

H. van Arkel, prisoner of war in Sumatra, was repatriated to Holland in 1946, left that country for Dutch Guiana as an employe of the Billiton Co., and remained in Surinam for about a year as manager of the Billiton bauxite mines. He left Surinam in July 1948 for Celebes, Indonesia, where the Company was exploring nickel ore deposits. His address at present is Mijnbouw Mij "Celebes," Malili, South Celebes, Indonesia.

David L. Watts has been made smelter superintendent for the Calumet & Hecla Consolidated Copper Co.

Bleecker L. Wheeler, formerly senior engineer with Ford, Bacon & Davis Inc., has opened a consulting office at 217 Broadway, New York City 7, in mining and industrial engineering.

David White, former geologist with the Alcoa Mining Co., has joined the staff of the Oregon State Department of Geology and Mineral Industries.

John B. White, Jr., metallurgical engineer with the Galigher Co., has been transferred from Butte, Mont., to Salt Lake City, Utah.

Robert T. Williams, of the University of Arizona, has been awarded the $750 scholarship provided by the Kennecott Copper Corp. to a senior student at the College of Mines there who is majoring in mining engineering. The prize was awarded on the basis of character, scholarship, leadership, and initiative.

Frank R. Zachar is general superintendent of the Christopher Coal Co., Pursglove, W. Va. He had been with the Pursglove Coal Mining Co.

• In Petroleum Circles

Allen D. Acomb, petroleum engineer with The Texas Co., has been transferred to the Company's Erath cycling plant at Erath, La.

Charles D. Axelrod, of 2416 Fenwick Rd., University Heights, Cleveland 18, Ohio, is occupied chiefly by buying and selling aluminum flat stock for the Alloys and Chemicals Co., Cleveland.

Max W. Ball resigned as director of the oil and gas division of the Department of the Interior on Dec. 1, and returned to private consulting work with offices in Washington, D. C. He lives at 1648 Foxhall Rd. Mr. Ball has been director of the oil and gas division since December 1946 and has had active experience in nearly all phases of the oil and gas industries. He served as chairman of the oil board of the Geological Survey, as engineer and law officer of the Bureau of Mines, as manager of exploration in the

Rocky Mountain region for the Shell Oil Companies, as president of the Argo Oil Co. and affiliated producing and pipe line companies, and during the war was with the PAW as special assistant to the deputy administrator. He had been in consulting practice since 1928 when not in Government service.

H. D. Spires

H. D. Spires has been transferred from the Tidewater Associated-Seaboard New Hope field in Franklin County, Texas, where he served as district petroleum engineer, to Kamay, where he has assumed his duties as district engineer and acting district foreman over the Tidewater Associated Oil Co. operations in the Wichita Falls area. His address is Box 204, Kamay, Texas.

Richard A. Barton, Jr., is a petroleum engineer trainee with The Texas Co. at Fort Worth, Texas. His mail goes to 836 N. Grand Ave., Gainesville, Texas.

Robert C. Beck is resident petroleum engineer for Michigan for the Superior Oil Co. He is staying at the Stearns Hotel, Ludington, Mich. He had been with the Michigan State Conservation Dept.

Gordon K. Bell, Jr., who is a researcher for the American Petroleum Institute, receives mail at 1155 Park Ave., New York City.

Eugene P. Bowler, who was chief of naval operations (OP-32), Mail and Dispatch Section, Navy Dept., Washington, is now addressed at P. O. Box 296, Shidler, Okla.

L. G. Chombart is manager of the Kansas division of the Schlumberger Well Surveying Corp., P. O. Box 1034, Wichita, Kans.

W. A. Clark, Jr., manager, foreign producing for The Texas Co., can be reached at 135 E. 42d St., New York City 17.

T. Dudley Cramer recently received his M. S. degree in petroleum engineering from Stanford University and is now employed by the producing department of the Standard Oil Co. of California at Taft, Calif.

Albert W. Dauer has the job of junior petroleum engineer with the Stanolind Oil and Gas Co. He is staying at the James Hotel, 219 NW 4th St., Oklahoma City, Okla.

Marshall Dayton, Jr., formerly of Norman, Okla., is now addressed at Drawer H., in care of the Sun Oil Co., Premont, Texas.

Robert H. Dickey has been employed as district geologist at Worland, Wyo., by the Pure Oil Co. since last July. He was a student at the University of Minnesota.

Robert E. Fearon is laboratory director for Well Surveys, Inc., Tulsa. He lives at 1430 S. Terrace Drive, Tulsa, Okla.

Thomas C. Frick, with the Atlantic Refining Co., has been transferred from Odessa, Texas, where he was district superintendent, to the post of division operations supervisor at Midland.

James H. Galloway, who was with the Humble Oil and Refining Co., Florey, Texas, is now addressed at Rm. 517, Hollingsworth Bldg., Los Angeles 14.

Joseph W. Walton

Joseph W. Walton, upon separation from the Army last summer, took some courses in real estate law and real estate brokerage at the University of Florida, and opened a real estate brokerage office in Vero Beach, Indian River County, Fla., on Dec. 1. He has made Vero Beach, Fla., his permanent residence and it is quite possible that he may add an engineering division to his present real estate activities sometime in the near future.

Howard K. Grant, home address 10524 Dorothy Ave., South Gate, Calif., is working for the Western Gulf Oil Co., Los Angeles, as a petroleum engineer.

Willard J. Larson, former manager of field operations for the Union Oil Co. of California, is now with the Yellowstone Oil Co., 629 S. Hill St., Los Angeles 14.

B. C. McRee, who is with the Union Producing Co., has been transferred from the Gulf Coast division to Shreveport, La.

Nace F. Mefford, Jr., Missouri School of Mines man, is working with the Ashland Oil and Refining Co., Ashland, Ky. His new address is 512 Center St., Henderson, Ky.

LeMoyne W. Myers, who has been addressed in care of the Creole Petroleum Corp., Maracaibo, Venezuela, is now reached in care of the Socony-Vacuum Oil Co. of Venezuela, Apartado 246, Caracas, Venezuela.

John A. Newman has been made division reservoir engineer for the Houston division of the Shell Oil Co. His new address is 4604½ S. Main, Houston.

Daniel B. Nolan, who has been studying at the University of California, Berkeley, is working as assistant geologist for the Capital Co., Los Angeles.

Sylvain J. Pirson, formerly associate professor of petroleum and natural gas engineering in the School of Mineral Industries at Penn State, joined the engineering department of the Stanolind Oil and Gas Co., Tulsa, Okla., as research reservoir engineer in January.

F. O. Prior, who has been president of the Stanolind Oil and Gas Co., Tulsa, is vice-president in charge of production of the Standard Oil Co. (Indiana), Chicago.

Michael R. Rector has a job as petroleum geologist with the Union Oil Co. of California, 702 Washington St., Olympia, Wash. He had been a student at the University of Washington.

Forest B. Rees is a geological trainee with the Carter Oil Co., P. O. Box 801, Tulsa, Okla.

Clarence W. Sanders, who was chief geologist for the Danciger Oil and Refining Co., is a consulting geologist in oil and gas exploration and development, with an address at 2413 Colonial Parkway, Fort Worth 4, Texas.

Douglas L. Saunders, who had been studying at the A&M College of Texas, is a petroleum engineer with the Sun Oil Co., Box 1312, Gladewater, Texas.

Herman E. Schaller has been made division sales manager of the Rocky Mountain-Mid Continent division of the Eastman Oil Well Survey Co., 1360 Speer Blvd., P. O. Box 1500, Denver.

Gene L. Scheirman, until recently a student at the University of Oklahoma, is a junior exploitation engineer with the Shell Oil Co., Houston. He gets his mail at 1423 N. W. 33rd St., Oklahoma City, Okla.

Albert T. Sindel, Jr., is division engineer for the Bay Petroleum Corp., and receives mail at Rt. 3, Seymour Rd., Wichita Falls, Texas.

Norman Soul is working as a geologist for the Pacific Western Oil Co. in Calgary, Alta. He had been with the McColl-Frontenac Oil Co.

J. Claire Sowers, Jr., former student at Penn State, is addressed in care of the Phillips Petroleum Co., City National Bank Bldg., Houston 2, Texas.

Charles E. Sturz is a paleontologist with the Tidewater Associated Oil Co., San Francisco. He receives mail at 915 College Ave., Menlo Park, Calif.

• In the Metals Branch

Robert E. Anderson has completed work for a B.S. degree in physical metallurgy at the University of California in Berkeley and is now employed by the University.

Mary Baeyertz has been named assistant chairman of the metals research department of Armour Research Foundation of Illinois Institute of Technology. Dr. Baeyertz, author of the recently published book, "Nonmetallic Inclusions in Steel," has been with the Foundation as a senior metallurgist since March 1, 1947. Previously she was supervisor of research at the South works of the Carnegie Steel Corporation. Dr. Baeyertz received her master's and doctor's degrees from Columbia University. She was awarded her bachelor's degree from Smith College. In her new position, Dr. Baeyertz will assist **W. E. Mahin,** chairman of the department, in general scientific supervision of numerous fundamental and applied research programs for industry and government agencies.

James L. Baker, who had been mill metallurgist for the Seymour Mfg. Co., Seymour, Conn., has become chief metallurgist with the Phosphor Bronze Corp., 2200 Washington Ave., Philadelphia, Pa.

Richard F. Baley is sales engineer for the Illinois Clay Products Co., Chicago. His mail reaches him at 20700 Ridgewood Ave., Cleveland 22, Ohio.

John H. Becque is night superintendent at the Tacoma smelter of the American Smelting and Refining Co., Tacoma, Wash. He had been a student at MIT.

R. L. Hallett

R. L. Hallett retired as chief chemist for the National Lead Co. and is now practicing as a consulting engineer with Arnold H. Miller. His office is at Rm. 2518, 120 Broadway, New York City 5.

Allan L. Brooks, who was a junior research engineer for the Air Reduction Co., is now working as metallurgical engineer in the standards engineering laboratory of the Sperry Gyroscope Co., Lake Success, N. Y.

A. Clemes is chief consulting metallurgist for New Consolidated Gold Fields Ltd. Mail reaches him at Box 1167, Johannesburg, S. Africa.

Dillon Evers, formerly on the staff of Michigan State College, is now on the staff of the school of chemical and metallurgical engineering at Purdue University, W. Lafayette, Ind.

Clarence T. Fletcher, who had been with the research division of the Mack Mfg. Corp., has gone to Braeburn, Pa., to work with the Braeburn Alloy Steel Corp.

Frank Foote, who was associate professor at the Columbia School of Mines, is now addressed at the Argonne National Laboratory, P. O. Box 5207, Chicago 80.

C. W. Hayes, formerly with the Sherwin F. Kelly Geophysical Services, is now with the Aluminum Co. of Canada, Arvida, Que.

Ray E. Huffaker, formerly a student at Purdue, is assistant lubrication engineer for the Ladish Co., manufacturer of forgings, at Cudahy, Wis. Mail reaches him at 1813 S. 28th St., Milwaukee 4, Wis.

Ivor Jenkins, with the research laboratories of the General Electric Co., Wembley, England, has been awarded the degree of Doctor of Science by the University of Wales for work in the field of metallurgy.

James G. Johnstone is now on the staff of Purdue University as an instructor in geology in the school of chemical and metallurgical engineering.

Herbert S. Kalish, formerly with the Electric Storage Battery Co., Philadelphia, is now working with Sylvania Electric Products Inc., Sylvania Center, P. O. Box 6, Bayside, L. I., N. Y.

Francis M. Krill is research metallographer for the Permanente Metals Corp., Spokane. His address is W. 1028 19th Ave., Spokane 9, Wash.

George E. Linnert works in the research laboratories of the Rustless division of the Armco Steel Corp., Baltimore, Md.

Robert T. Luedeman, formerly with the Braden Copper Co., Rancagua, Chile, has a job as metallurgist with the Weston Electrical Instrument Co., Newark, N. J. He receives mail at 192 Hillside Ave., Leonia, N. J.

H. Gerald Maiers

H. Gerald Maiers until last August was with the engineering department of the General Chemical Co. At that time he joined the development engineering department of the National Lead Company's Titanium division, where he is now employed. His address is 23 Park Ave., Cranford, N. J.

M. Merlub-Sobel has been appointed to the newly created post of associate professor of chemical engineering and metallurgy at the Hebrew Technical College, Haifa, Israel, the only engineering and technological school in Israel, and, for that matter, in that part of the Near East. His present work, that of manager of one of the divisions of Machleket Ha-Yitzur, will continue simultaneously with teaching and consultation in the fields of chemical and metallurgical engineering.

Gordon M. Miner is sales engineer for the Goodman Mfg. Co. His home is at 812 Baver Ave., Charleston, W. Va.

Ralph L. Nelson, Jr., resigned from the Tennessee Coal, Iron and Railroad Co. on Nov. 30 to enter the employ of Thomas Foundries, Birmingham, Ala., as a chemist.

M. N. Ornitz is assistant superintendent of National Alloy Steel, division of the Blaw-Knox Co., Blawnox, Pa.

F. A. Paciotti has a job with the Tin Processing Corp., Texas City, Texas, as a research engineer. His mail reaches him at 4801-R½, Galveston.

John W. Russell, who had been studying at Carnegie Institute of Technology, is working as apprentice engineer for the Mesta Machine Co., West Homestead, Pa. His home address there is 4723 Brierly Court West.

Ralph Sheppard is working as a research engineer for the St. Joseph Lead Co. of Monaca, Pa. He was a student at the South Dakota School of Mines.

George E. Sibbett, who has been a partner in the Coulter Sibbett Steel Co., is president of the Allen Fry Steel Co., Los Angeles. His home address is 1126 Greenwich St., San Francisco.

T. J. C. Smid, formerly chief engineer of the metallurgy department of the Billiton Co., is now working for a Bolivian tin company and is addressed at Fundicion de Estano, Oruro, Bolivia.

Austen J. Smith left the Lunkenheimer Co. as assistant director of research Nov. 1 to become connected with Michigan State College at East Lansing as associate professor of metallurgical engineering.

H. D. Stark has retired as assistant to the vice-president in charge of operations of the Jones & Laughlin Steel Corp. For many years he was general superintendent of the Pittsburgh works. Mr. Stark has completed 49 years of service with J&L. He started at the age of sixteen as a draftsman in the engineering department of the Pittsburgh works. After serving as superintendent of the machine shop, the steel works, and the blooming mill departments, he was appointed assistant general superintendent of the Pittsburgh works in 1927. He served as general superintendent from 1936 until August 1947, when he was appointed assistant to the vice-president in charge of operations.

Wilfred Sykes, president of the Inland Steel Co., Chicago, has been representing the U. S. Army on a one-way commission to report on organization by the American and British commission. He made a trip to Germany and other spots in Europe in December.

Robert M. Wagner returned to Stanford University in 1946 to obtain his doctorate in organic chemistry. He is now research chemist for the General Electric Co. at the Hanford engineering works, Richland, Wash.

Walter M. Weil, who has been general manager of the National Smelting Co., is general manager of the Enesco Corp., producers of magnesium alloys, Box 1791, Cleveland 5, Ohio.

Clarence Zener, professor of metallurgy at the Institute for the Study of Metals, University of Chicago, is serving as special lecturer and consultant in physical metallurgy in the department of mining and metallurgical engineering of the University of Illinois. He delivered his first lectures Nov. 18 and 19 on "The Problem of Fraction" and "The Acoustical Spectrum of Metals." Dr. Zener, a native of Indianapolis, received his undergraduate degree at Stanford University and his doctor's degree at Harvard, and was successively Sheldon traveling fellow, National research fellow, research fellow of Bristol University, and instructor in physics at Washington University and at CCNY before becoming principal physicist of the Watertown (Mass.) Arsenal in 1942.

Obituaries

H. Clarence Horwood

An Appreciation by C. C. Huston

In the sudden death of H. Clarence Horwood in Vancouver, B. C., on Oct. 30, his many friends and the mining industry have suffered a real and grievous loss. "Clare"—as he was invariably known—had been enjoying a holiday at the coast when he died.

Born in Ottawa in 1905, his career and progress in the field of mining geology had been direct and constant. He had won academic recognition with a B.A.Sc. in geological and mining engineering, at the University of British Columbia in 1930; an M.Sc. in geological engineering, at Queen's University in 1931; and a Ph.D. in geological and mining engineering, at MIT in 1934.

In 1936 he was appointed assistant geologist on the staff of the Ontario Department of Mines, after gathering experience in field work with the Geological Survey of Canada in Alberta, British Columbia, and Manitoba; and during an interval of private practice in Great Bear Lake. In addition, he also acted as assistant geologist in the Bureau of Economic Geology, in Ottawa. In 1943 Clare was appointed district geologist for Northwestern Ontario, residing at Port Arthur, and in 1947 was recalled to the headquarters staff of the Ontario Department of Mines in Toronto. In the course of his expanding career with the Department, he did work that took him into the Casummit Lake, Superior Junction, Red Lake, Little Long Lac, and Missanabie areas. He was very active during the war years in the strategic mineral field.

His report on the "Geology and Mineral Deposits of the Red Lake Area," a publication of the Ontario Department of Mines, is an outstanding contribution to Canadian geological knowledge. Although he was the author of more than thirty other papers and articles of great interest, the Red Lake report is the most outstanding, from every aspect, demonstrating as it does the basic knowledge of the writer, making a clear exposition of the information so meticulously gathered, and more particularly reflecting the calm confidence which the writer so obviously felt in his work and the future of this area and country.

His devotion to the interests of his profession is best demonstrated by briefly recounting his affiliation with the AIME, the Society of Economic Geologists, the Association of Professional Engineers of the Province of Ontario, and the Prospectors and Developers Association. In proper recognition of his contributions to geological knowledge, he was elected a Fellow of the Royal Society of Canada.

His wider humanities are only partially indicated by recalling that he found time in a busy professional life to be a member of the Junior Chamber of Commerce in Port Arthur where he originated and supervised a half-million dollar community center. He was also a director of the Rotary Club in that city and a member of the Masonic order.

A deserved and sincere tribute was recently paid to Clare by the Ontario minister of mines, Mr. Frost, speaking for his colleagues and fellows: his friends and associates will always remember his sincerity, vitality, warm heart, ready smile, and steady hand.

Walter Gifford Scott

AN APPRECIATION BY P. D. I. HONEYMAN

With the death of Walter Gifford Scott, superintendent of the Inspiration Cons. Copper Co. leaching plant, the metallurgical profession and all his associates have suffered a severe and shocking loss. Walter Scott, apparently well when he retired for the night, passed away in his sleep on Dec. 4, 1948.

Walter Scott was born on May 8, 1890,

Necrology

Date Elected	*Name*	*Date of Death*
1928	C. P. Barrett	Mar. 29, 1948
1907	George M. Colvocoresses	Dec. 14, 1948
1910	James S. Douglas	Jan. 2, 1949
1911	Charles Enzian	Dec. 7, 1948
1937	Chester H. Gibbons	Apr. 14, 1948
1917	Robert W. Handley	June 29, 1948
1886	David G. Kerr	Oct. 18, 1948
1920	Walter G. Scott	Dec. 4, 1948
1928	C. Wesley Smith	Feb. 10, 1948
1910	Frank M. Warren	Oct. 16, 1948
1944	Gordon T. Williams	Sept. 19, 1948
1908	Howard P. Zeller	Dec. 10, 1948

in Detroit, Mich. His early schooling was in Detroit, and his professional training in mining and metallurgy from the Michigan College of Mines in Houghton. Early in his career he went to work for the Anaconda Copper Mining Co. in Anaconda, Mont., where he was engaged in experimental and research work in extractive metallurgy. For a brief interlude during World War I, Scott, as assistant to the late Harold Aldrich, was loaned out to engage in the operation of a small smelting plant at Ladysmith on Vancouver Island, B. C. Following this, he returned to Anaconda and resumed his former work.

In 1918 the development of the ferric sulphate leaching process was being launched by Inspiration in Arizona. Mr. Scott joined the staff of the Company at that time and advanced steadily until he became superintendent of leaching, which position he occupied at the time of his death.

Walter Scott's name will always be associated with the successful development of this leaching process. In the early days he was foreman of the pilot plant in which the process was worked out. Following this early work he contributed greatly to the building of the commercial plant and, as assistant superintendent, guided its operation patiently and thoroughly through its early growing pains up to its present-day high state of efficiency.

In 1929, the late Harold Aldrich and Walter Scott jointly published a paper, on leaching and electrolytic precipitation of copper at Inspiration, which is a classic, constantly referred to by those interested in this phase of hydrometallurgy. In later years Walter Scott was always consulted on leaching problems, on which he was considered an outstanding authority.

Along with his accomplishments as a metallurgist, he was a good citizen, ever ready to do his part for the betterment of community life. He served several terms as president of the Cobre Valle Country Club, was a past president of the Globe Rotary Club, and also served as president of the Gila County Chamber of Commerce. He was a 32nd degree Scottish Rite Mason.

Walter Scott did his job and did it well. His death leaves a gap that will be hard to fill, but in his work he has established a foundation on which his associates can continue to build and expand the process of hydrometallurgy.

Proposed for Membership

Total AIME membership on December 31, 1948, was 15,580; in addition 4069 Student Associates were enrolled.

ADMISSIONS COMMITTEE

Albert J. Phillips, Chairman; James L. Head, Vice-Chairman; George B. Corless, T. B. Counselman, George C. Heikes, W. B. Plank, P. D. Wilson, E. M. Wise.

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In the following list C/S means change of status: R, reinstatement; M, member; J, Junior Member; A, Associate; S, Student Associate; F, Junior Foreign Affiliate.

ARIZONA

Ajo—TRAVIS, GEORGE ALBERT. (C/S—J-M). Engineer, Phelps Dodge Corp.

Bisbee—BUELL, LLOYD THOMAS. (R—M). Chief clerk, Copper Queen branch, Phelps Dodge Corp.

Douglas—FOARD, JAMES EDWIN. (J). Test engineer, Phelps Dodge Corp.

Humboldt — TOMKINSON, ELMER RAYMOND. (M). Mine superintendent, Iron King branch, Shattuck Denn Mining Corp.

Phoenix—MANNING, ROGER I. C. (R—M). Mining engineer, Arizona Dept. of Mineral Resources.

Tucson — WINTERS, VERNE WILLIAM. (M). Metallurgist, Eagle-Picher Mining and Smelting Co.

Willcox—COOPER, JOHN ROBERTS. (C/S—J-M). Geologist, U. S. Geological Survey.

ARKANSAS

Fort Smith—BOYD, BERNARD DEGEN. (R,C/S—JA-M). Vice-president and manager, Boyd Excelsior Fuel Co.

CALIFORNIA

Glendale—RHODES, JOSEPH RICHARD. (A). Vice-president and manager of refractories division, Gladding, McBean & Co.

Hammonton—HAAK, VINCENT ALFRED. (C/S—S-J). Sampler, research department, Yuba Cons. Gold Fields.

Lompoc — SCHUKNECHT, GEORGE G. (R,C/S—J-M). Superintendent of quarries and mines, Johns Manville Products Corp.

Los Angeles—DURGIN, LAURANCE IRA. (M). Geologist and petroleum engineer, self-employed. GLOVER, PATRICK NORMAN. (C/S—S-J). Exploitation engineer trainee, Shell Oil Co. HAWKINS, ROBERT RUSSELL. (M). Secondary recovery engineer, Signal Oil and Gas Co. RAY, HORATIO C. (R—M). Consulting engineer (retired).

Orinda — LINDSAY, JAMES EDWARD. (M). Reserves engineer, Standard Oil Co. of California.

Pasadena—DUWEZ, POL E. (M). Associate professor of mechanical engineering, California Institute of Technology. STOLZ, FRED C. (M). Petroleum engineer, Stanley & Stolz.

San Francisco—FARNOW, FREDERICK WILLIAM. (M). Manager, federated metals division, American Smelting and Refining Co. HEWITT, EDWARD THOMAS. (M). Manager, mining equipment division, Electric Steel Foundry Co. SELFRIDGE, JOHN SOLEY, Jr. (M). Plant superintendent, federated metals division, American Smelting and Refining Co.

COLORADO

Denver — AHLBORG, WILLIAM THOMAS. (M). Secretary, assistant to president, Denver Equipment Co. BARKER, CLAUDE L. (C/S—J-M). Assistant sales manager, E. I. du Pont de Nemours & Co. EMRICK, JOHN HOMER. (M). District manager, Joy Mfg. Co.

Idaho Springs — FAIRCHILD, GERARD LANHAM. (C/S—S-J). Geologist, American Smelting and Refining Co.

CONNECTICUT

Darien—KNAPP, THOMAS JULIAN. (A). Assistant vice-president, Freeport Sulphur Co.

Greenwich — MODEL, JEAN. (M). President and owner, Sonrisa Mining Co.

Old Greenwich—RUSSELL, JOHN C. (R,C/S—J-M). Senior process engineer, consulting engineering department, The Dorr Co.

DISTRICT OF COLUMBIA

Washington — NARTEN, PERRY FOOTE. (C/S—S-J). Geologist, U. S. Geological Survey. OLUND, HENNING EKSTROM. (R—M). Mining engineer, mining branch, Bureau of Mines.

FLORIDA

Bartow — CHILDS, WILLIAM BURTON. (M). Construction engineer, American Cyanamid Co. RAULERSON, JOHN DERIEUX, Jr. (J). Assistant mining superintendent, Florida phosphate division, International Minerals and Chemical Corp.

Pierce—ANDERSON, THOMAS JOHN, Jr. (M). Engineer, American Agricultural Chemical Co.

IDAHO

Burke—LINDSTROM, PHILIP MARTIN. (C/S—J-M). Mining engineer, Hecla Mining Co.

ILLINOIS

Glencoe—YOUNG, WILLIAM PEARCE. (R,C/S—JA-M). President, Bell & Zoller Coal and Mining Co.

Libertyville—CLAUSEN, CARL FREDERIK. (M). Manager of mfg. research, Portland Cement Assn.

Rockford—MILLER, LEE GEORGE. (M). Chief metallurgist, Greenlee Bros. & Co.

Wilmette—DICKEY, ROBERT McCULLOUGH. (R,C/S—J-M). Chief sales engineer, Bucyrus-Erie Co.

INDIANA

East Chicago—BAJOR, MENCESLAUS JOSEPH. (C/S—S-J). Metallurgical trainee, Inland Steel Co. HECHINGER, CARL JOSEPH. (C/S—S-J). Research and development metallurgist, Eagle-Picher Co.

Fort Wayne—CHEW, JOHN CARROLLTON. (C/S—S-J). Production engineer, Phelps Dodge Copper Products Corp.

Hammond—JONES, WILLIAM NORRIS. (M). Electric melter, Republic Steel Corp.

Terre Haute—MATTHEWS, MAX A. (M). President, Templeton-Matthews Corp.

KANSAS

Baxter Springs—SEXTON, KENNETH PAUL. (A). General manager, Consolidated Supply Co.

Ellinwood—MEYERS, JEAN WARREN. (J). Junior petroleum engineer, Stanolind Oil and Gas Co.

Eureka—CAWTHON, PETE W., Jr. (C/S—S-J). Trainee engineer, Phillips Petroleum Co.

Great Bend—PUGH, WILLIAM LEE. (J). Sales engineer, Lane-Wells Co.

McPherson—ZOLLER, JACQUES WILLIAM. (C/S—S-J). District exploitation engineer, Shell Oil Co.

Wichita—HOLLOW, WALTER BYRON. (M). Drilling superintendent, Bridgeport Oil Co. KOESTER, EDWARD ALBERT. (M). Consulting petroleum geologist. LUND, CARL I. (J). Sales representative, Moorlane Co. NATION, WILLIAM BENJAMIN. (R,C/S—S-M). Petroleum engineer, Co-operative Refinery Assn.

Zenith—MORGAN, JOHN VICTOR. (R,C/S—S-J). Field engineer, Stanolind Oil and Gas Co.

KENTUCKY

Jenkins—BERRY, JOHN KIRKMAN. (M). Chief production engineer, Consolidation Coal Co.

Louisville—ANDERSON, HARRY LeROY, Jr. (C/S—S-J). Ceramic engineer, Republic Steel Corp.

Wheelwright—PACE, EDWARD MINOR. (R,C/S—S-J). Engineer, Inland Steel Co.

LOUISIANA

New Orleans—KOKESH, FRANK PHILLIP. (M). Harvey district engineer, Schlumberger Well Surveying Corp.

MARYLAND

Silver Spring—LURIE, WILLIAM. (M). Metallurgist, U. S. Naval Gun Factory.

MASSACHUSETTS

Brookline—FITZPATRICK, JOHN McNEIL. (C/S—S-J). Research metallurgist, division of industrial co-operation, MIT.

Pittsfield—STONE, FRANCIS GILMAN. (C/S—J-M). Research metallurgist, Works laboratory, General Electric Co.

MICHIGAN

Detroit—GORTON, CLAIR ALLEN. (A). Metallurgical engineer, Hoskins Mfg. Co.

Marquette—DeHAAS, CLYDE TIFFANY. (A). Owner and manager, C. T. DeHaas Co. DREVDAHL, ELMER RANDOLPH. (C/S—S-J). Engineer, Vicar mine, Jones & Laughlin Ore Co.

MINNESOTA

Hibbing—STUART, JAMES REEVE. (R—M). Chief engineer, Meriden Iron Co.

Nashwauk—SWANSON, PAUL PETER. (R,C/S—A-M). Superintendent, Cleveland-Cliffs Iron Co.

MISSISSIPPI

Natchez—WHATLEY, ERROLL RENETH, Jr. (C/S—S-J). Petroleum engineer, California Co.

MISSOURI

Bonne Terre—OHLE, ERNEST LINWOOD. (C/S—J-M). Geologist, St. Joseph Lead Co.

Herculaneum—SHERMAN, JOHN WILLIAM. (R,C/S—J-M). General foreman, St. Joseph Lead Co.

Rolla—FUNK, CAMPBELL WILLIAM FLOYD. (C/S—S-J). Metallurgist, powder metallurgy section, Bureau of Mines. GORSKI, CHARLES HENRY. (M). Metallurgist, Bureau of Mines. WOODWARD, THEODORE. (J). Instructor in geology, Missouri School of Mines.

St. Louis—HAM, NEAL. (M). Branch manager, Ingersoll-Rand Co.

MONTANA

Butte—RENOUARD, EDWARD IGNATIUS, Jr. (M). Assistant general superintendent of mines, Anaconda Copper Mining Co.

NEVADA

Pioche—HYDE, DONALD EDWIN. (R,C/S—S-J). Junior engineer, Combined Metals Reduction Co.

Winnemucca—SPITZER, ROBERT BOWMAN. (M). Superintendent, Rossi mine, Merced mill, Baroid sales division, National Lead Co.

NEW JERSEY

Chatham—LIEBIG, EDWARD OTTO. (C/S—J-M). Production metallurgist, Baker & Co.

Franklin—McKECHNIE, DONALD. (M). Mill superintendent, New Jersey Zinc Co.

Morristown—ACKERMAN, DAVID HARTON. (J). Geologist, Jones & Laughlin Ore Co.

Netcong—FRANZ, HENRY WILLIAM. (C/S—J-M). Metallurgist, Singmaster & Breyer.

New Brunswick—WYATT, JAMES LUTHER. (C/S—S-J). Development engineer, titanium division, National Lead Co.

Passaic—MACIORA, JOSEPH GEORGE. (C/S—S-J). Metallurgist, Wright Aeronautical Corp.

Phillipsburg—SHEPHERD, BENJAMIN FRANKLIN. (R,C/S—A-M). Chief metallurgist, Ingersoll-Rand Co.

NEW MEXICO

Carlsbad—NELSON, RICHARD BENTON. (J). Junior mine engineer, Potash Co. of America.

Silver City—WALTON, MARSHALL RHODES. (M). President, M. R. Walton & Associates.

Vanadium—NEUMAN, JAMES VINCENT, Jr. (C/S—J-M). Assistant to manager, Bayard department, U. S. Smelting Refining and Mining Co.

NEW YORK

Brookhaven—COOK, HARRY CLARE. (J). Associate engineer, Brookhaven National Laboratories.

Brooklyn—BUGLIONE, VINCENT JOSEPH. (R,C/S—S-J). Metallurgist P-1, N. Y. Naval Shipyard. ROSS, EARL WARREN. (R,C/S—S-J). Metallurgist, N. Y. Naval Shipyard. YOKELSON, MARSHALL VICTOR. (M). Research metallurgist, General Cable Corp.

Flushing—NININGER, ROBERT D. (R.C/S—S-J). Geologist, assistant to the manager, raw materials operations, Atomic Energy Commission.

New York—DeKANSKI, LEON M. (R—M). Project engineer, The Dorr Co. MECHELYNCK, ANDRE L. (C/S—S-J). Trainee, American Radiator and Standard Sanitary Co. WEIDNER, PAUL NELSON. (M). Petroleum engineer, Standard Oil Co. (New Jersey).

New York Mills—WILLIAMS, GRIFFITH, Jr. (M). Supervisor of methods, Revere Copper and Brass Co.

Syracuse—CHUTE, NEWTON EARL. (M). Assistant professor of geology, Syracuse University.

OHIO

Cleveland—BURGESS, CHARLES OWEN. (R,C/S—JA-M). Technical director, Gray Iron Founders' Society. WILBUR, JOHN SMITH. (A). Sales representative, Cleveland-Cliffs Iron Co.

Gates Mills—POTTER, HORACE W. (C/S—J-M). Consultant (steel), Arthur G. McKee & Co.

Steubenville—McCABE, CHARLES GRIFFITH. (M). Foreman of open-hearth metallurgy, Wheeling Steel Co.

OKLAHOMA

Bartlesville—CARPENTER, ANDREW HOWLAND. (C/S—S-J). Junior engineer, Cities Service Oil Co. SMITH, SHOFNER. (J). Senior Reservoir engineer, Phillips Petroleum Co.

Oklahoma City—SEELY, DWIGHT H., Jr. (J). Junior process engineer, Sohio Petroleum Co. SNEED, ROBERT WHITE. (M). District sales manager, Eastman Oil Well Surveying Co.

Okmulgee—NEWMAN, ROBERT CLARK. (C/S—S-J). Petroleum engineer, Thomas S. Newman, Geologist and Civil Engineer.

Stillwater—SCHLEMMER, ALFRED EUGENE. (J). Instructor in mechanical engineering, Oklahoma Agricultural and Mechanical College.

Tulsa — BAUMAN, WILLARD EDWIN. (J). Production engineer, Gulf Oil Co. JARRELL, L. C. (C/S—S-J). Petroleum engineer trainee, The Texas Co. OCHELTREE, TEMPEST MATTHEWS. (R,C/S—S-M). Chief engineer, Devonian Co. WILDER, LAWRENCE BERNARD. (J). Junior research engineer, Stanolind Oil and Gas Co.

Webb City—DENNY, JACK PERSHING. (J). Engineer, Phillips Petroleum Co.

OREGON

Hillsboro — McWILLIAMS, JACK HUGH. (M). Geologist, Alcoa Mining Co.

PENNSYLVANIA

Beaver Falls—SUMMERFIELD, CHRISTIAN JOHN. (M). Research associate, Mellon Institute.

Bethlehem — SELLERS, PAUL EDWARD. (M). Quarry superintendent, Bethlehem Steel Co.

Exton—VON STROH, GERALD F. H. (M). Director, mining development program, Bituminous Coal Research.

Feasterville—SCHUCH, EDWARD ANTHONY. (M). Chief engineer, Aero Service Corp.

McKeesport — KELLER, RICHARD LATCHFORD. (M). Fellow, Mellon Institute.

Philadelphia — HESS, GEORGE L. (M). Sales engineer, Aero Service Corp.

Uniontown—HAMILTON, JAMES L. (M). Manager, safety and operating departments, Republic Steel Corp.

SOUTH DAKOTA

Belle Fourche—MIDDLETON, DAVID MAXWELL. (C/S—J-M). Plant superintendent, Aladdin Wyoming plant, National Lead Co.

Lead—WARREN, LYLE GEORGE. (M). Structural design, Homestake Mining Co.

TEXAS

Alice—BARB, GLEN WAYNE. (J). Petroleum engineer, Magnolia Petroleum Co.

Austin—CLARK, GLYNN ALDEN. (C/S—S-J). Research fellow, Texas petroleum research committee, University of Texas. PLAZ, LUIS. (M). Petroleum inspector, Venezuelan Government.

Beaumont — DUBLIN, JAMES ROLAND. (C/S—S-J). Junior petroleum engineer, Humble Oil and Refining Co.

Borger — DANA, PHILIP LYMAN. (M). Geologist, J. M. Huber Corp.

Dallas — BOCK, MORRIS. (M). Chief chemist, Southwest division, Sun Oil Co. LIPSON, LEONARD B. (J). Senior physicist, field research laboratories, Magnolia Petroleum Co. RENFRO, HAROLD BELL. (M). Geologist and petroleum engineer, Stodel Oil Co. SMITH, GERALD LLOYD. (J). Petroleum engineer, Magnolia Petroleum Co. STORMONT, DAVID HENRY. (M). District editor, *The Oil and Gas Journal*.

El Paso—DEISLER, PAUL F. (C/S—A-M). Management consultant, self-employed.

Fort Worth—WILSEY, LAWRENCE EARL. (C/S—S-J). Junior petroleum engineer, Stanolind Oil and Gas Co.

Freer—MURPHY, GORDON JOSEPH WARNER. (J). Petroleum field engineer, The Texas Co.

Houston—BEEZLEY, JOEL E. (C/S—S-J). Production engineer, Pure Oil Co. BEILHARZ, CARL FRICHOT. (M). Division reservoir engineer, Pure Oil Co. BERNHARD, WILLIAM E. (M). Petroleum engineer, Ginther, Warren & Ginther. GUEST, HENRY GRADY. (M). Senior engineer, Schlumberger Well Surveying Corp. LEGERON, ROBER AIME. (M). Manager of field operations, Schlumberger Well Surveying Corp. POYNER, HERBERT FLAKE, Jr. (C/S—S-J). Graduate student, University of Texas. SELIG, AUGUST LEWIS. (M). Consulting geologist.

McAllen—RIDGWAY, ROBERT JOSEPH. (C/S—S-M). Petroleum engineer, Sun Oil Co.

Midland—LITTLE, WILLIAM NORMAND. (M). Division engineer, Tide Water Associated Oil Co. MINTZ, JOHN MOORE. (J). Associate engineer, Tide Water Associated Oil Co.

Wichita Falls—REYNOLDS, JOHN CLIFFORD STANLEY. (C/S—S-J). Research assistant, department of petroleum engineering, University of Texas.

UTAH

Bingham Canyon—BARLOW, VINAL STOKER. (M). General mine foreman, Kennecott Copper Corp. McNEILIS, THOMAS ROSS. (M). Electrical foreman, Utah copper division, Kennecott Copper Corp. WILLEY, RICHARD HAVEN. (R,C/S—S-M). Assistant general drill and blast foreman, Utah copper division, Kennecott Copper Corp.

Lark—COFFEY, JAMES ARTHUR. (A). Chief clerk, Lark mine, U. S. Smelting Refining and Mining Co.

Salt Lake City—EARLY, LAWRENCE WILLIAM. (M). Sales service representative, Hercules Powder Co. RICHARD, FRED VINCENT. (M). Safety engineer, American Smelting and Refining Co.

VIRGINIA

Arlington—BRANDENBURGER, OSCAR LOUIS. (R—A). Chief, materials supply, Civil Aeronautics Administration.

WASHINGTON

Richland—CALLEN, ALFRED COPELAND, Jr. (J). Metallurgist, Hanford works, General Electric Co.

Seattle—STRANDBERG, THEODORE R. (A). Mining engineer, Strandberg & Sons.

Vancouver—JENSEN, JAMES HENRY. (M). Plant and chemical engineer, Pacific Carbide and Alloys.

WISCONSIN

Milwaukee — MAROLD, FRANK. (R,C/S—S-J). Application engineer, export sales department, Allis-Chalmers Mfg. Co.

WYOMING

Casper—ROBBINS, RAYMOND WILLIS. (M). District geologist, The Texas Co.

Cody—HAMMAR, HAROLD DAVID. (J). Junior petroleum engineer, Stanolind Oil and Gas Co. POLLOCK, CHARLES BERTRAND. (J). Junior petroleum engineer, Stanolind Oil and Gas Co.

Lusk—GALLIVAN, JOHN C. (C/S—J-M). Rocky Mountain division superintendent, Wood River Oil and Refining Co.

MANITOBA

Flin Flon—HUNT, EDWIN S. W. (M). Assistant mine superintendent and chief mining engineer, Hudson Bay Mining and Smelting Co.

ONTARIO

Ottawa—IGNATIEFF, ALEXIS. (M). Mining engineer, division of fuels, Bureau of Mines.

Toronto—DEAN, WILLIAM JOHN. (M). Manager, Kennex, Ltd.

ARGENTINA

Jujuy—RICCI, LUCIANO. (M). Chemical laboratory chief, Institute de Geologia y Mineria de la Universidad Nacional de Tucumun.

VENEZUELA

Caracas — STILLWELL, KENNETH LAWRENCE, Jr. (J). Trainee, The Texas Co. WILLIAMS, DAVID BOWEN. (M). Chief scout, Shell Caribbean Petroleum Co.

ENGLAND

London—LANCE, ALFRED EMERSON. (R—M). Principal control officer, ores and minerals, Germany section, British Foreign Office.

LIBERIA

Monrovia—REILINGH, ALBERT. (J). Geologist, Liberia Mining Co.

FEDERATED MALAY STATES

Perak—KENNEDY, ERROL MOSTYN. (C/S—S-J). Junior assistant, Gopeng Cons. Ltd.

INDIA

Bombay—MEHTA, PESI EDI. (C/S—S-M). Technical assistant, Tata Industries, Ltd.

Oorgaum—DAVID, JOSEPH PETER. (M). Inspector of mines, department of mines and explosives, Government of Mysore.

NEW SOUTH WALES

Broken Hill—FISHER, GEORGE READ. (R—M). General manager, Zinc Corp.

NEW CALEDONIA

Noumea—ROUTHIER, PIERRE JEAN. (M). Chief of the geological mission, Office de la Recherche Scientifique Coloniale.

Student Associates

Elected December 15, 1948

Thomas M. Anderson.....Univ. Ariz.
George H. Bailey.....Univ. Idaho
James H. Barnett....Colo. Sch. Mines
Lawrence E. Barrett..Colo. Sch. Mines
Boris J..Bermes.....Colo. Sch. Mines
Hubert E. Berninghausen
Colo. Sch. Mines
Billie L. Bessinger...Colo. Sch. Mines
Ervin G. Bilderback.....Texas A&M
Robert R. Blair.....Okla. A&M
John L. Bolles.....Colo. Sch. Mines
Ollen N. Bradford.....Okla. A&M
Tyler Brinker.....Colo. Sch. Mines
Richard S. Bryson....Colo. Sch. Mines
Floyd D. Burnside...Colo. Sch. Mines
David L. Caldwell.....Colo. Sch. Mines
John W. Caldwell.....Colo. Sch. Mines
Walter M. Chapman..Colo. Sch. Mines
Chih Wen Chen.....Ill. Inst. Tech.
David C. Childers....Colo. Sch. Mines
Ben B. Chomick.....Colo. Sch. Mines
Charles C. Coenen....Colo. Sch. Mines
Robert H. Coleman.....Okla. A&M
Alva G. Comer.....Okla. A&M
Daniel M. Cooper.....Colo. Sch. Mines
William M. Denton.....Okla. A&M
William P. Donovan....Ill. Inst. Tech.
Joseph R. Driear.....Colo. Sch. Mines
Wilfried Drolet, Jr.....Univ. Ariz.
Joseph C. DuBois, Jr...Colo. Sch. Mines
Richard J. Durning...Colo. Sch. Mines
Arthur J. Dyson.....Colo. Sch. Mines
Aly A. El-Gazzar.....Okla. A&M
Burnett E. Ellis.....Univ. Mo.
Foster E. Endacott...Colo. Sch. Mines
Richard K. Epps.....Texas A&M
Hugh W. Evans.....Colo. Sch. Mines
Ernest C. Fitch, Jr.....Okla. A&M
Handren K. Fitzgibbons
Colo. Sch. Mines
Walter S. Forbes.....Colo. Sch. Mines
Martin S. French.....Colo. Sch. Mines
Richard H. Fulton....Colo. Sch. Mines
Jeremy V. Gluck.....Univ. Mich.
Dennis E. Gregg.....Colo. Sch. Mines
Niles E. Grosvenor...Colo. Sch. Mines
Alexander F. Halcrow.Colo. Sch. Mines
Harley H. Hartman....Colo. Sch. Mines
James S. Hastings....Colo. Sch. Mines
John A. Heffelfinger.....Okla. A&M
Robert N. Hendry....Colo. Sch. Mines
Donald C. Herron.....Colo. Sch. Mines
J. D. Hicks.....Okla. A&M
John C. Holden.....Okla. A&M
William R. Holman.....Univ. Calif.
Joseph P. Hopkins.....Okla. A&M
William E. Hopkins.....Univ. Mich.
Kenneth W. Hottinger.Colo. Sch. Mines
Donald L. Hovorka....Colo. Sch. Mines
Wei-pei Hu.....Univ. Utah
Shao-Chi Huang.....Ill. Inst. Tech.
Douglas O. Hukkanen.....Univ. Calif.
John B. Hundley, Jr....Stanford Univ.
John G. Jaka.....Colo. Sch. Mines
John F. Jarrell.....Queen's Univ.
Glen O. John.....Adelaide Univ.
Thomas C. Keating....Colo. Sch. Mines
Norman Korn .....Colo. Sch. Mines
Kenneth B. Larson....Colo. Sch. Mines
William A. Libby..Texas Mines & Met.
David R. Lohr.....Colo. Sch. Mines
Murrell D. Long.....Colo. Sch. Mines
David M. Mathews....Colo. Sch. Mines
William W. May.....Colo. Sch. Mines
Robert C. McCain....Colo. Sch. Mines
Sidney J. McDuff.....Univ. Ariz.
Ira E. McKeever, Jr...Colo. Sch. Mines
Donald T. Moore.....Colo. Sch. Mines
Edward A. Morrison...Colo. Sch. Mines
Robert H. Muench....Colo. Sch. Mines
Roger R. Nelson.....Colo. Sch. Mines
John D. Noll.....Colo. Sch. Mines
Hugh W. Olmstead....Colo. Sch. Mines
Homer C. Osborne.....Texas A&M
Harold B. Overstreet..Colo. Sch. Mines
Robert S. Padboy.....Colo. Sch. Mines
William L. Parker....Colo. Sch. Mines
Herbert L. Peel.....Okla. A&M
Eugene M. Pohoriles.....Okla. A&M
Fred F. Polizzano....Bklyn. Poly. Inst.
Dale A. Reagan.....Okla. A&M
Joseph C. Richardson, Jr...Texas A&M
Harold J. Riggott.....Colo. Sch. Mines
James A. Robertson.....Okla. A&M
Clovis E. Rodelander.....Okla. A&M
Charles W. Rohler....Colo. Sch. Mines
David A. Rowland....Colo. Sch. Mines
Leonard B. Saltzman....Ill. Inst. Tech.
Lawrence Sama.....Bklyn. Poly. Inst.
Norman Schapiro.....Bklyn. Coll.
Treadwell C. Schmitt.Texas Mines&Met.
Darrell G. Shurtliff....Colo. Sch. Mines
Richard C. Siegfried..Colo. Sch. Mines
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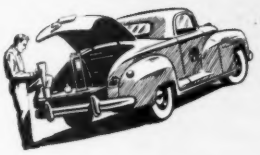

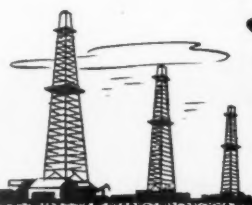

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T.P. 2543

SEMIAUTOMATIC POWER-OPERATED DRILLING MACHINERY

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ABSTRACT

To cope with the problems encountered when drilling at greater depths and to reduce the amount of physical effort required on the part of drilling crews in making round trips, a new type of semiautomatic power-operated drilling machinery has been developed which permits round trips to be made without the drill pipe being touched by hand. This equipment consists of hydraulically operated tongs which perform the stabbing, spinning, and tonging operations, and two power-operated racking units mounted in the derrick for carrying the pipe to and from the center of the hole and positioning it on the mat and in the rack. With this equipment all of the operations of the various units are controlled remotely by manipulation of hydraulic valve levers and electric switches.

INTRODUCTION

As horsepower rises to meet the demand for deeper drilling, it is necessary to increase the weight of surface drilling equipment. Also, the duration of repetitive operations in making round trips to change bits is greatly increased with depth. Harder formations encountered at greater depths reduce bit life rapidly, resulting in more frequent round trips and in some instances more time is consumed in changing bits than in drilling.

Since the introduction of the first rotary employed to drill for oil in 1895[1], there has been relatively little change in the general procedure for making up, breaking out, stabbing, and racking drill pipe in making round trips to change bits. The conventional method of making round trips with the drill pipe requires that drilling crews lend strenuous physical assistance to manually operated tools.

Although many new devices have been developed to improve efficiency, increase speed of making round trips, improve safety, and reduce the amount of physical effort required in handling drill pipe, it is considered a vital necessity to substitute automatic or semiautomatic power-operated machinery for many of our more or less manual operations if extremely deep drilling is to be carried out successfully on a production basis in the same manner as our shallower drilling of today.

Field tests have been made of remotely controlled power-operated tongs, spinner, stabber, and racking equipment. The tongs, which include a built-in pipe spinner, are mounted on a column, are capable of gripping and supporting the weight of a 90-foot stand of drill pipe, and are provided with means for moving the pipe vertically as well as to and from the center of the hole. The racking equipment consists of two units, one at the level of the conventional monkey board and the other at the first girth on the ladder side of the derrick.

Most of the physical effort of making round trips with drill pipe has been eliminated in that all of the operations of tonging, spinning, stabbing, and racking of pipe on the floor are controlled by an operator in a seated position by manipulation of hydraulic and electric valve levers and buttons. The driller is relieved of operating the cathead, leaving only the hoisting and slips to be controlled. Complete round trips are made without the drill pipe being touched by the drilling crews.

Although the speed of pulling or running a single stand with the power-operated equipment is approximately the same as that with conventional equipment, it is possible to maintain this rate for long periods, whereas fatigue slows crews working conventionally during round trips, especially under adverse weather. After completing round trips with this equipment, drilling crews are not exhausted, consequently, are able to perform effectively their duties while drilling, which is essential for maximum over-all efficiency. Safety is substantially improved as the derrickman performs his duties from a platform enclosed by rails and the tong lines and spinning chain are eliminated from the derrick floor. The hazards encountered in racking drill pipe on the floor and in stabbing are also eliminated. Figure 1 shows a drawing of a derrick equipped with the power-operated drill pipe handling equipment.

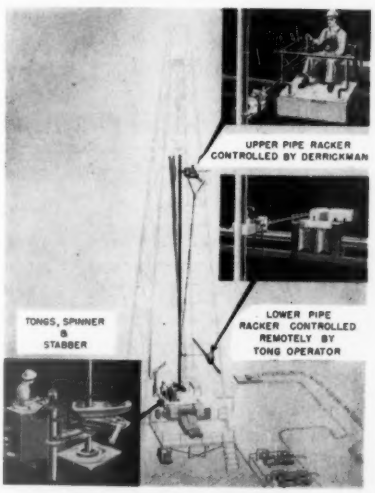
UPPER PIPE RACKER CONTROLLED BY DERRICKMAN
TONGS, SPINNER & STABBER
LOWER PIPE RACKER CONTROLLED REMOTELY BY TONG OPERATOR

FIGURE 1 — POWER OPERATED TONGS SPINNER, STABBER AND PIPE RACKER.

Manuscript received at office of the Branch August 30, 1948. Paper presented at Division Fall Meeting, Dallas, Texas, Oct. 4-6, 1948.
[1] References are given at the end of paper.

METHOD

Remotely Controlled Pipe Racker

The remotely controlled pipe racker consists of two electrically powered arms, one between the eleventh and twelfth girths and one just above the first girth on the ladder side of the derrick. Each arm, which consists of a three-inch diameter, twelve-foot long screw having two threads per inch and three equally spaced keyways through the threads parallel to the axis of the screw, is caused to move in and out perpendicular to the side of the derrick in a horizontal plane. Each arm or screw is mounted on a carriage which in turn is supported on tracks attached to the ladder side of the derrick in openings which permit eight feet of travel for the upper unit and ten feet for the lower unit across the side of the derrick.

Upper Racking Unit

The upper racking unit, consisting of the carriage and arm, is equipped with a working platform having dimensions approximately the same as those of the conventional monkey board. This platform is enclosed with a rail 30 inches in height and is provided with a swivel seat adjustable in height. The end of the racking arm, which moves to and from the center of the derrick, is provided with a claw which automatically encircles the pipe on contact and is used for positioning the upper end.

Figure 2 (Page 29) shows a view looking down from the top of the derrick of the traveling monkey board and racking arm just before the claw engages a stand of drill pipe and Figure 3 shows a lower view of the same equipment after the pipe has been engaged by the claw.

Figure 4 shows a view of the racker removing pipe from the rack and Figure 5 shows a lower view of the racker moving pipe into the elevators. Figure 6 shows the position of the racker at the time the elevators are latched.

Referring to Figures 2 and 5, the claw consists of a "U" shaped fork that encloses 180 degrees of the circumference of the pipe and a hydraulically operated latch which is automatically closed around the pipe on engagement. The claw latch is actuated by an arm which controls a solenoid valve admitting hydraulic fluid to a cylinder and piston. The claw assembly is provided with a knuckle joint and a pressure release as a safety measure in case the elevators are accidentally lowered onto it.

Transverse movement of the carriage and monkey board is produced by a stationary 3-inch diameter lead screw mounted parallel to the carriage track shown in Figure 3. A nut on the screw is powered by a 2-horsepower, 220-volt, 3-phase electric motor drive. The racking arm screw is likewise powered by a 3-horsepower electric motor driving a nut supported by bearings on the carriage assembly frame.

Control of the upper racker is accomplished by a single lever, shown in Figure 2, which has eight positions for actuating microswitches that determine the movement of the racking arm and carriage. Separate movement of the arm and carriage can be obtained or a combination movement of both will occur by proper positioning of the controller. The claw is released from the pipe by pushing the button shown on the control lever in Figure 2. Microswitches are provided with adjustable stops which provide means for limiting the travel of the carriage and racking arm screws to prevent jamming and to provide means for bringing the units automatically to a predetermined position.

Lower Racking Unit

The lower racking unit is essentially the same as that of the upper without the working platform. It consists of a carriage which moves back and forth across the side of the derrick and is provided with a power-operated screw or arm which travels out and in for positioning the lower end of the drill pipe. The end of the racking arm moves to and from the center of the derrick and is connected by a linkage to an auxiliary elevator which is provided to support the weight of the pipe and transfer it from the tongs to an elevated pipe mat. Figure 7 shows the lower racker transferring a stand of pipe from an elevated mat into the jaw of the make-up tong and Figure 8 shows a rear view of the lower racking unit mounted in the derrick just above the first girth.

The auxiliary elevator, shown in Figure 9, consists of a "U" shaped member which is built to fit around the drill pipe being racked. A hydraulically operated spring returned cam with teeth located in one leg of the "U" shaped member is rotated into engagement with the pipe for hoisting. The elevator unit is provided with means for swiveling to accommodate any lean of the pipe that may be encountered. A hydraulic cylinder, mounted at the eleventh girth, is connected by a cable to the auxiliary elevator and is energized from the control panel on the derrick floor. The control for the lower racker is similar to that described for the upper unit and is mounted on the tong panel. Figure 10 shows the auxiliary elevator supporting a stand of pipe as it is being transferred from the tongs.

To facilitate moving, both the upper and lower power-operated pipe rackers, shown in Figure 11, are mounted on a single skid. The racking arm screws are pivoted on their frames and anchored in a position parallel to the carriage tracks.

Power-Operated Tongs

The power-operated tongs, shown in Figure 12, consist of two pipe-gripping units mounted on a side bracket attached to a hydraulically operated column with its base anchored rigidly to the derrick substructure. The upper portion of the column to which the tongs are attached is capable of a vertical travel of three feet, permitting operation at any height in that range and allowing the driller a liberal tolerance in setting the slips. The back-up tong unit is provided with a hydraulically operated gate and latch, actuated by a valve on the control panel, and a gripping cylinder which is energized by sequence valves causing the lower unit to grip the tool joint automatically after the gate has been closed. The make-up tong, mounted just above and on the back-up tong, is provided with an identical mechanism for opening and closing the gate and latch but requires the manipulation of a special control lever to produce a gripping force on the pipe. This tong is also provided with a pair of power driven rollers, shown in Figure

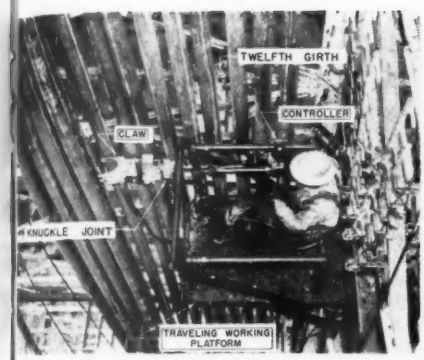

FIGURE 2
UPPER RACKING UNIT WITH CLAW APPROACHING STAND OF PIPE

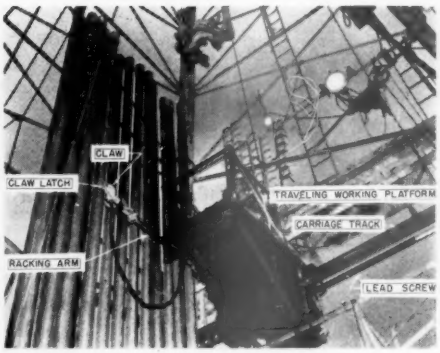

FIGURE 3
DRILL PIPE BEING REMOVED FROM RACKING FINGERS BY UPPER RACKER

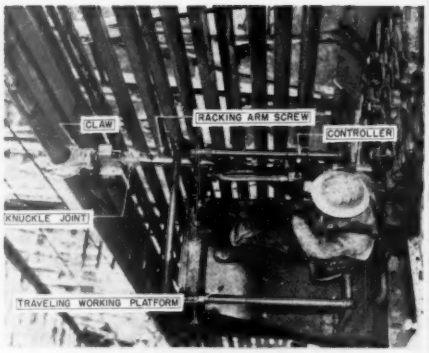

FIGURE 4
DRILL PIPE BEING REMOVED FROM RACKING FINGERS BY UPPER RACKER

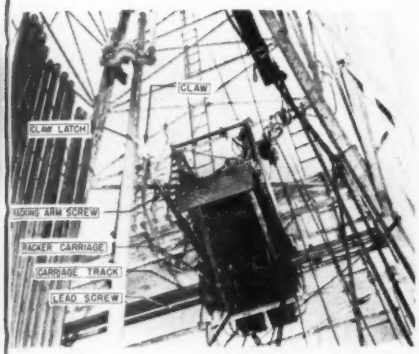

FIGURE 5
UPPER RACKER MOVING DRILL PIPE INTO ELEVATORS

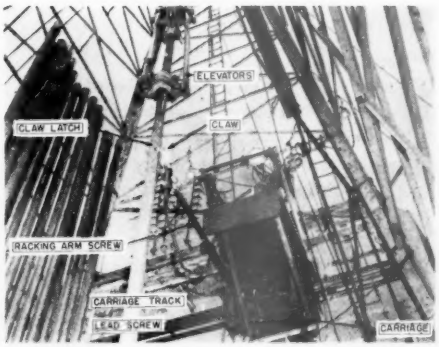

FIGURE 6
ELEVATORS LATCHED AROUND DRILL PIPE BY UPPER RACKER

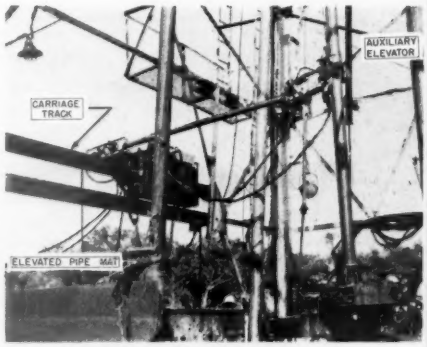

FIGURE 7
PIPE RACKER TRANSFERRING A STAND OF DRILL PIPE FPOM MAT TO TONGS AT EXCHANGE POSITION

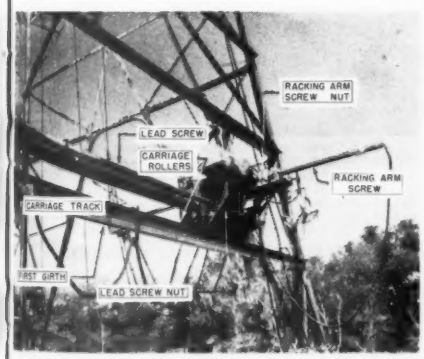

FIGURE 8
REAR VIEW OF LOWER PIPE RACKER

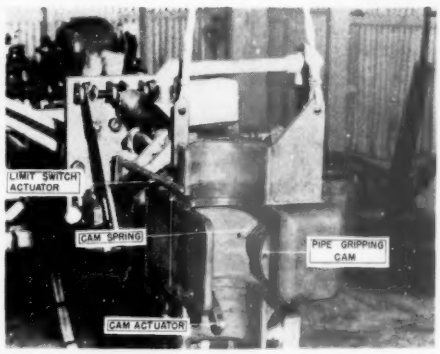

FIGURE 9
SINGLE STAND AUXII IARY ELEVATOR

FIGURE 10
AUXILIARY ELEVATOR SUPPORTING A STAND OF DRILL PIPE AS IT IS REMOVED FROM THE TONGS

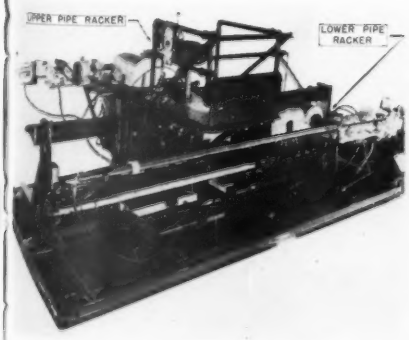

FIGURE 11
UPPER AND LOWER PIPE RACKERS MOUNTED ON SKID

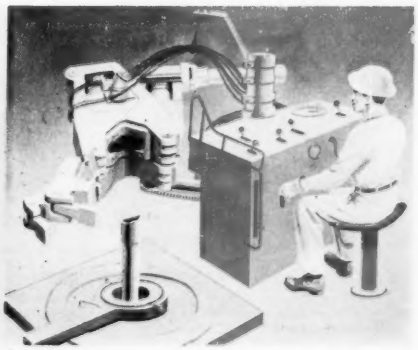

FIGURE 12
POWER-OPERATED TONGS

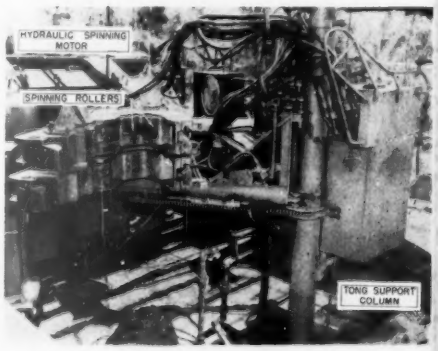

FIGURE 13
POWER TONG SPINNING ROLLERS

FIGURE 14
MAKING UP DRILL PIPE WITH POWER TONGS

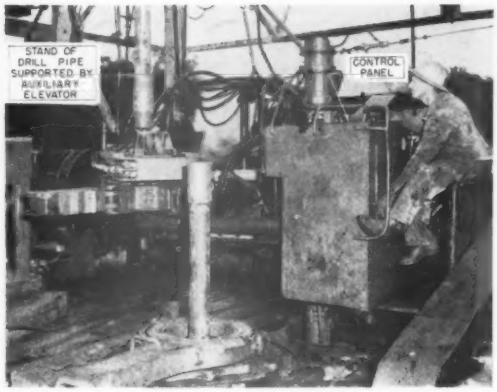

FIGURE 15
POWER TONGS JUST BEFORE MOVING UP TO GRIP AND SUPPORT STAND OF DRILL PIPE

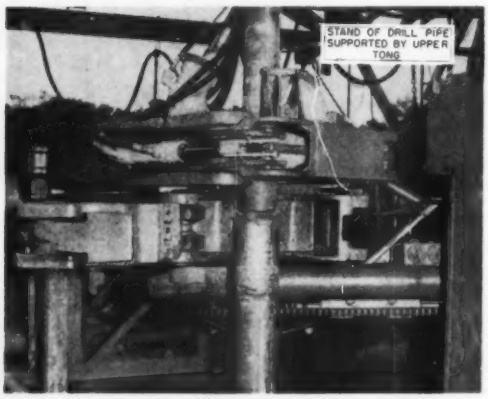

FIGURE 16
POWER TONGS STABBING DRILL PIPE

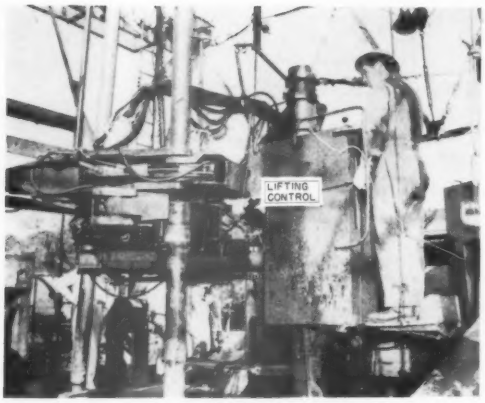

FIGURE 17
POWER TONGS LIFTING STAND OF DRILL PIPE AFTER SPINNING OUT

FIGURE 18
POWER TONGS MOVING INTO POSITION TO BREAK TOOL JOINT

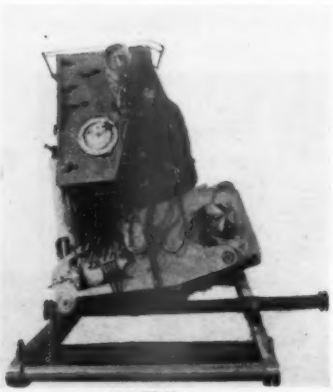

FIGURE 19
END VIEW OF POWER TONGS MOUNTED ON SKID

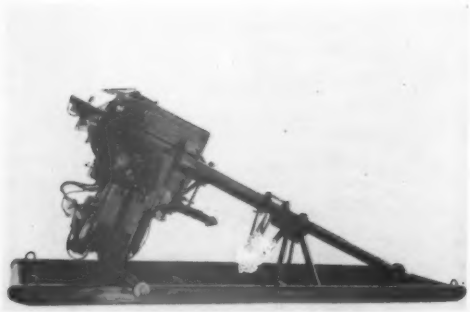

FIGURE 20
SIDE VIEW OF POWER TONGS MOUNTED ON SKID

13, which are moved through the tong jaws by hydraulic pressure for engaging the pipe to produce the spinning operation.

The spinning rollers are capable of developing 1,950-foot pounds of torque when operating at 2,500 pounds per square inch hydraulic fluid pressure. A maximum force of 28,000 pounds can be exerted against the rollers for spinning. The spinning rollers which are six inches in diameter and capable of a speed of 147 rpm are powered by a hydraulic motor driving through sprockets and chains.

Make-up or break-out with the tongs is accomplished by a scissor action produced by a hydraulic cylinder, shown in Figure 14, connecting the two outer ends of the tongs. The tongs are capable of gripping from 2⅞-inch tool joints up to and including 8-inch OD drill collars. Each of the tongs can exert a gripping force of 400,000 pounds at an operating pressure of 2,500 pounds per square inch. The maximum tong make-up pressure is 591,000-pound inches and the maximum break-out pressure is 1,440-000-pound inches when operating at 2,500 pounds per square inch. Normal operating pressure is 1,500 pounds per square inch although 2,500 pounds per square inch is used for maximum torque and gripping force.

The hydraulically operated column, tong support, and tongs are capable of supporting the weight of a stand of 5-inch OD drill pipe. During normal operations, the lower racker is used for moving the stands of drill pipe to or from an exchange position which is approximately 4 feet from the center of the rotary in the direction of the drawworks on an arc scribed by rotation of the tongs on the column.

With the stand of drill pipe in the exchange position supported by the rackers and auxiliary elevator, Figure 15 shows the position of the tongs just before being raised to grip the tool joint in the case of going in the hole or the position after releasing the long grip in coming out of the hole. Figure 7 shows the tool joint in the jaw of the make-up tong. The tongs are shown in the stabbing position in Figure 16. Figure 17 shows the position of the unit prior to closing the gate on the back-up tong and spinning going in the hole or immediately after spinning when coming out. Figure 18 shows the power tong unit moving onto the drill pipe after the slips have been set for breaking the tool joint.

The current procedure, used in coming out of the hole is to break the tool joints with the tongs, release the grip, and open the gate of the back-up or lower tong, and spin out with the rotary table. An alternate method to accomplish this is to rotate the stand of pipe out with the spinner.

Power for the spinner, tongs, and controls is supplied by a 35-horsepower pump and precharged piston and cylinder-type hydraulic accumulator.

Figures 19 and 20 show the power tongs mounted on a skid for moving. The entire unit, including controls, are unitized, requiring the connection of two hydraulic lines and one electrical plug.

Operation of the Remotely Controlled Power Tongs and Pipe Racker

All of the movements of the upper end of the drill pipe are by the racking arm, the derrickman's only manual operation being to unlatch the elevators when coming out of the hole. All tonging operations and pipe handling on the derrick floor are controlled remotely by the tong operator from either a standing or seated position on the control panel platform attached to the moving portion of the tong support column. One man is required on the floor for latching and unlatching the elevators.

Coming Out of the Hole

By the time the slips have been set, the jaws of the power tongs have been moved around the tool joint at the proper height following which the gates are latched, pressure is applied to the gripping jaws, and a 30-degree scissor action is produced to break the tool joint. The upper tong grips the lower end of the stand being broken out and produces a slight upward force as the spinning operation is accomplished with the rotary table. After the break-out operations are completed on the floor, the derrickman pulls the upper end of the stand in the direction of the monkey board by means of the power-operated arm and in turn unlatches the elevators with the assistance of the catline. As soon as the threads clear the tool joint box, the lower end of the stand is carried to the transfer position by the break-out tong accomplished by rotating the tongs about the column through an arc of approximately 50 degrees. The transfer position, approximately four feet from the center of the rotary, allows clearance for the traveling block to return to the floor. The lower racking arm supporting the auxiliary elevator engages the pipe, lifts it from the tong, and moves it to and positions it on the elevated mat. The lower racker then returns automatically to the approximate vicinity of the exhange positions. The derrickman racks the upper end simultaneously with the lower.

Going Into The Hole

Both the upper and lower racking arms engage and pick up a stand of pipe from the mat and racking fingers and move it to the transfer position. The derrickman centers the racking arm and holds it in an approximately vertical position. With the lower end of the pipe supported by the auxiliary elevator moved to the transfer position by the lower racker, the make-up tong jaws move up around the tool joint which, in turn, is energized for gripping and supporting the entire stand. The operator then rotates the tong unit through a 50-degree arc in the direction of the center of the hole and lowers the column to allow the tool joint pin to enter the box. The make-up tong grip is released and the spinning rollers are energized, rotating the stand of pipe in a clockwise direction until shouldered. The make-up is completed by a clockwise rotation of the make-up tong to produce the final tightening. While the tonging operation is in progress, the derrickman moves the upper end of the stand into the open elevators, Figures 5 and 6, which automatically latch around the pipe. A conventional side door type elevator with a special toggle latching linkage is used with this equipment. While the stand of pipe is being lowered into the hole and the empty elevators returned to the top of the pipe, the tong operator and the derrickman have moved the next stand into the transfer position.

CONCLUSION

Although the power-operated tongs, spinner, stabber, and racking equipment have been used for drilling two wells to depths below 10,000 feet, the equipment is yet in the experimental stage and final development will be reached as drillers and their crews use it and suggest modifications and improvements.

REFERENCE

1. I. F. Bingham: Present Trend in Rotary Well Drilling and Completion. *The Science of Petroleum*, Volume 1, Pages 406-429.

DISCUSSION

☆

By J. M. Clark, The Chicago Corp., Corpus Christi, Texas

The semi-automatic drilling equipment described in this paper is certainly a big stride toward eventual full automatic operation. There are, however, certain considerations which must be taken into account as the new devices are developed. The chief advantage is in relieving the driller of several routine operations which he must perform on a conventional drilling rig while making a "round trip". Most new conventional rigs have placed too many operations in the driller's hands.

A question of prime importance is, can all of the equipment described in this paper be instantly and surely disengaged in the event of power or mechanical failure? If this is not true, the drill stem might "freeze" in open hole in an emergency.

Conventional drilling equipment provides a dependable means of lifting drill pipe stands from the floor mat to the height required for tool joint make-up and vice-versa. Equipment to mechanically swing the stands to the desired positions could be very advantageous, but it would seem that a mechanism which also lifts the stands duplicates a function of the hoisting elevators and results in too many complicated devices. In addition, the weight of a stand while being lowered to the floor mat of a conventional set-up, helps accelerate the traveling blocks on the empty trip down. When a large number of lines are strung, traveling blocks accelerate slowly, thus lengthening trip time.

Drilling rigs have increased in size to meet the demand for deeper drilling, but it should be noted that in spite of heavier equipment, the new rigs and the derrick floor tools are easier on the crew than the older lighter rigs. Tools are easier to handle, quite often, not because they are automatic, but because they are better designed and balanced.

Much of the fatigue resulting from repetitive operations of round trips is mental rather than physical, and semi-automatic tools will not necessarily be of great help. In fact, a reasonable amount of physical effort helps to relieve the monotony of a long round trip. Efficient automatic equipment which lessens the skill required to operate, promotes safety and frees personnel for other duties, should compensate for the extra investment and complexity, but semi-automatic equipment may retain the main disadvantages of both automatic and manually operated tools; that is, the intricate devices necessary for semi-automatic operation are, of course, more subject to breakdown than conventional tools, but they may not lessen the mental fatigue or required operational skill. Judging solely from a brief study of this paper, the tools described would seem to come under the latter category. ★ ★ ★

THE CORE RECORDER

CLARK MILLISON, CONSULTING GEOLOGIST, TULSA, OKLAHOMA

ABSTRACT

The core recorder, a mechanical instrument for determining the exact depth at which core is recovered, drilled up or lost, is described. Examples of charts from the recorder are explained and interpreted. The uses of the core recorder are discussed.

INTRODUCTION

In the experience of geologists and engineers during coring operations on drilling wells, many will recall the times when a full core was not recovered and particularly when the requirement was urgent that they know exactly what part of the core was lost. To make this determination, the core recorder was designed. Its uses are many, and only the most obvious will be presented here. Although this discussion will be limited to drilling wells for petroleum, the core recorder can be used in any type of coring operation.

The principle of the core recorder is the proportional reduction of the motion of core entering or dropping out of the core barrel to a stylus moving in such a manner as to record the reduced motion on a chart. The time element is registered on the same chart by the revolution of a clock which turns the chart drum. Thus the exact amount of core entering or dropping out of the core barrel is charted and the time of such entry or exit from the core barrel is precisely correlated to the depth at which the core is recovered or lost. Lack of movement of the stylus which is revealed by the continued revolution of the chart drum indicates that no core is entering the barrel.

The principles are accomplished by an instrument placed inside of the core barrel. A cylinder which contains the clock and mechanical apparatus has a diameter smaller than that of the core barrel. Near the top of the cylinder is an eighteen hour clock which turns the drum that contains the chart. Near the bottom of the instrument is a serrated wheel which by friction against the inside of the core barrel is turned as core enters or drops out of the barrel.

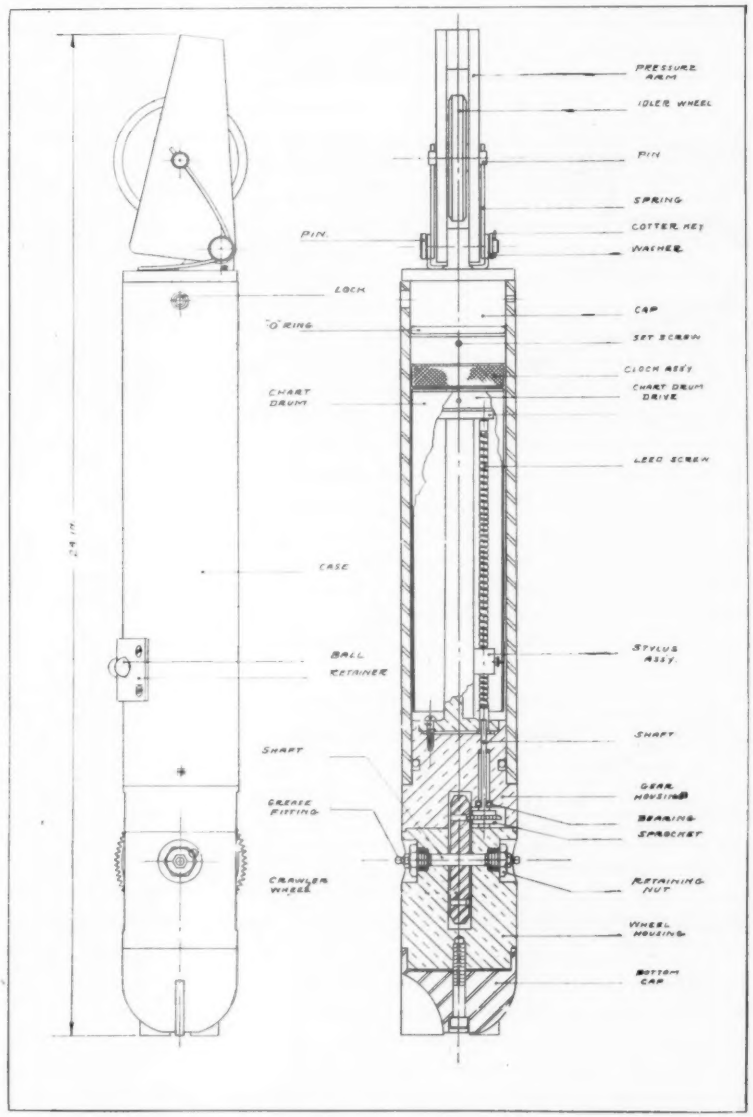

FIG. 1 — DETAILED VIEW OF THE CORE RECORDING INSTRUMENT.

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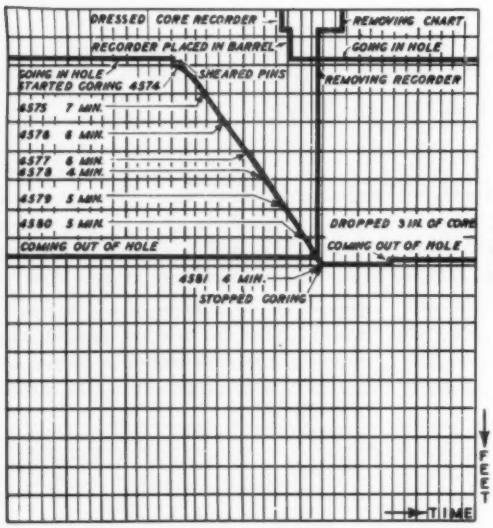

CHART 1—CORE RECORDING CHART WHERE FULL RECOVERY WAS OBTAINED.

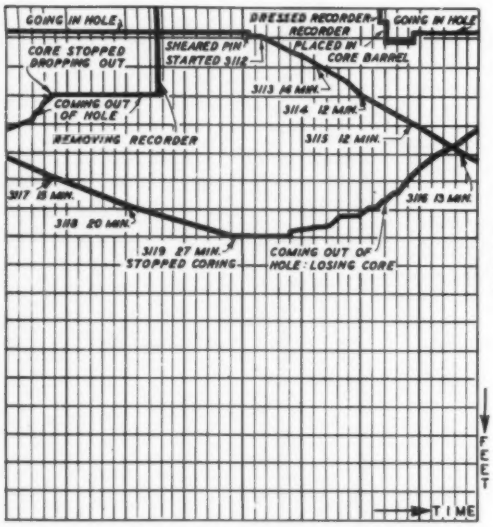

CHART 2—SHOWING THAT CORE IS NOT RECOVERED UNDER SOME CIRCUMSTANCES.

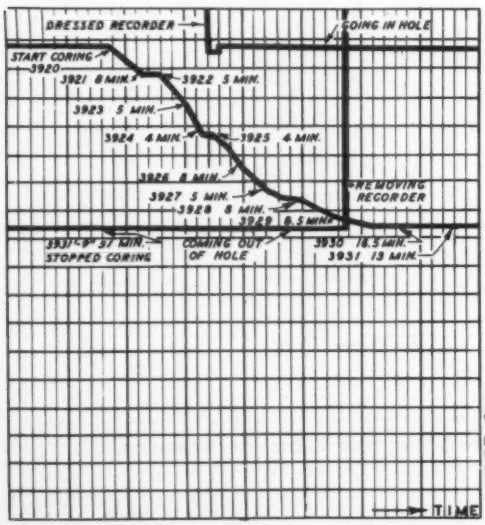

CHART 3—SHOWING THE RESULTS OF A DEFECTIVE CORE CATCHER.

CHART 3

To insure a positive friction against the barrel, a spring loaded idling wheel at the top of the instrument causes a stress against a ball bearing fulcrum below the center of the instrument which forces the serrated wheel against the inside of the barrel. The movement of the serrated wheel is transmitted through a sprocket to a lead screw on which a spring loaded stylus travels. The distance the stylus travels is in direct ratio to the length of the core barrel.

The vertical movement of the instrument is recorded on the chart by the stylus, and at the same time the clock is turning the chart horizontally. Consequently if core is entering the barrel, the stylus moves upward. If the core is being drilled up and none is entering the barrel, the stylus does not move but the clock continues to turn the chart. If core drops out of the barrel, the stylus moves downward.

Time of the coring operation is kept at the surface in the usual manner except that the time the recorder is placed in the barrel and the time it is removed are also recorded. Thus, the time it takes to go into the hole, the time required for each foot drilled and the time that is necessary to come out of the hole is known. A sort of closed traverse is recorded. Correlation of the time kept at the surface against the time recorded by the clock will reveal all of the events that occurred during the entire operation.

As examples of the charts made by the core recorder, the following cases offer many of the various types of occurrences. The first shows a case in which full recovery was obtained. The horizontal line near the top is that made by the stylus while resting on the plug during the operation of going in the hole. The first vertical line indicates when the pins in the plug were sheared. As core entered the barrel and the clock turned the chart, the individual feet cored were recorded. When the coring operation ceased, the stylus discontinued its movement and a horizontal line was made. As the core bit was lifted off of bottom, three inches of core dropped out as recorded by the small downward movement of the stylus. The next vertical line shows when the core was removed from the barrel.

The second chart shows that core is not recovered under several different

circumstances. The second foot cored, from 3921 to 3922 feet, was not recovered although it took only five minutes to drill the foot. Conversely the last foot and nine inches took 44 minutes to drill and none was recovered. This record is from a well that cored from the Simpson dolomite into "Wilcox" sandstone. One and one half feet of sandstone was recovered. By analyzing the chart, the top of the sandstone could be determined at 3926½ feet and this information could not be determined from the core, samples, or drilling time. To show an example of the detail which can be expected from the core recorder, an analysis of this chart is presented.

The third chart shows the results of a defective core catcher. The sandstone which was cored is about 13 feet thick in this area. Eight feet of sandstone were drilled when it was decided to core. The coring time indicated that a slower drilling formation was encountered after coring five feet. Two more feet were cored, and the barrel was removed from the hole. Only two feet of core was recovered, and it was shale The presumption was made that five feet of sandstone had been drilled up, and only the two slower drilling feet, which were presumed to be shale, were recovered. But the core recorder showed that full recovery had been obtained and that five feet had dropped out of the barrel on the way out of the hole. Only the top two feet were left in the barrel, and the entire core was shale below the sandstone which had thinned at this particular location to eight feet.

If it is attempted by coring to find the top of a producing formation, the core recorder can be used with great benefit. Loss of core would make it difficult to establish the exact top of the producing zone and consequently the geological information, the drill stem test seat, and the casing seat would be questionable.

If a loss of core occurs while coring a producing formation the core analysis is inexact. A side wall core at the exact depth where core is lost can be taken and it will supply the lacking data. A comparison of the core recording chart with the electric log will supply oftentimes the type of rock that was lost from the core.

Perhaps one of the most beneficial result of the use of the core recorder is the possibility of improving coring technique. While using the recorder, the data such as pump pressure, rotary table speed and weight, should be kept and correlated with recovery percentages. The experience with the recorder has been too limited to offer any concrete suggestions, but it is believed an accumulation of such data will offer improvements in technique and in the amounts of core recovery.

Only coring operations in holes drilled for petroleum have been considered in this paper. The core recorder might be useful in mining operations, holes cored for dam and bridge sites, and water wells. The instrument is simple enough to be adaptable to any coring operation. ★ ★ ★

T.P. 2547

EFFECTS OF TRANSIENT CONDITIONS IN GAS RESERVOIRS

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ABSTRACT

A simple disturbance in a gas reservoir travels with a finite velocity which is nearly independent of the amplitude of the disturbance. As a result very complex transients may be set up which seriously affect observation at a well. The time of transient is much longer than commonly supposed.

INTRODUCTION

A change in pressure at a gas well is not propagated through the reservoir instantaneously but with a definite finite velocity. Knowledge of the period of this transient is of value because:

1. Observations of pressure and flow-rate during the transient may affect interpretation of back-pressure tests.

2. Interference effects between wells may be used to determine continuity of formation.

3. Additional information concerning the physical characteristics may possibly be deduced from the behavior of a well during the transient.

MATHEMATICAL DEVELOPMENT

It will be assumed that the well is initially closed in and that the pressure is constant throughout the reservoir. As the initial disturbance passes outward from the well it is further assumed that a logarithmic pressure distribution is established between the most distant point reached and the well, so that:

$$\phi = (\phi_r - \phi_w)\left(\frac{\log\frac{r_x}{r_w}}{\log\frac{r}{r_w}}\right) + \phi_w \quad . \quad (1)$$

Manuscript received at office of the Branch September 15, 1948. Paper presented at Branch Fall Meeting, Dallas, Texas, Oct. 4-6, 1948.

r_x = distance to any point between r and r_w
r = radius of drainge
r_w = radius of well
ϕ = potential (P for incompressible fluids, P^2 for perfect gases)

Up to the time the effect reaches the point r the production from the well will be:

$$W = \frac{\pi\ t\ r^2 f}{P_b}\ (P_r - P_m) \quad . \quad (2)$$

W = volume produced
t = sand thickness
f = fractional porosity
Pr = reservoir pressure
P_m = average pressure between r and r_w
P_b = atmospheric Pressure

All pressures will subsequently be stated in atmospheres and the constant P_b will be omitted.
This will be produced at a rate:

$$\frac{dw}{d\theta} = \frac{\pi\ t\ k}{\mu}\ \frac{(P_r^2 - P_w^2)}{\log\frac{r}{r_w}} \quad . \quad (3)$$

P_w = pressure at the well
k = permeability
θ = time
μ = viscosity

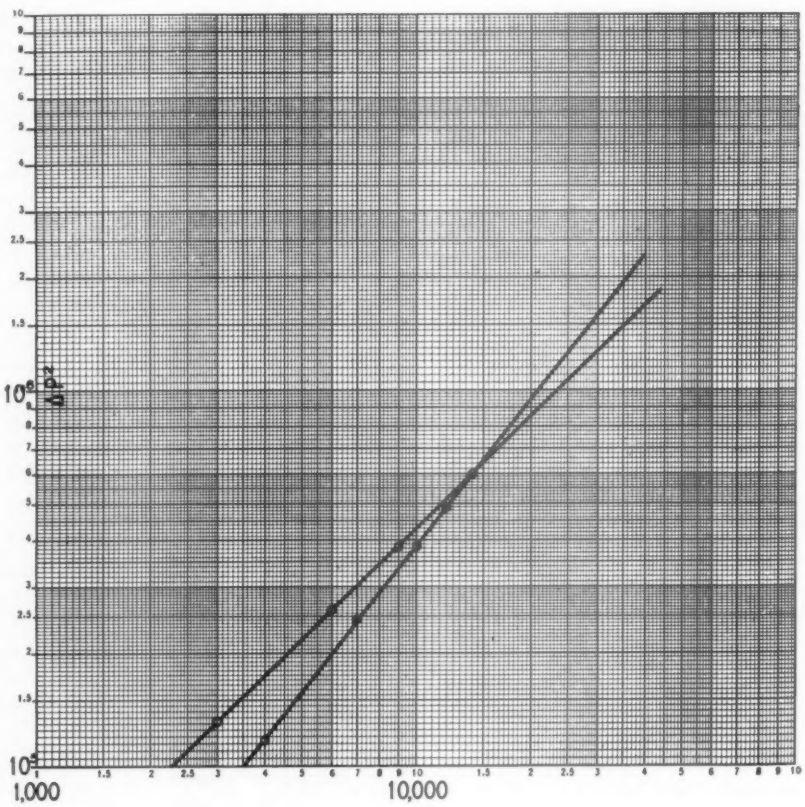

FIG. 1 — EFFECT OF TRANSIENT CONDITIONS ON BACK PRESSURE TEST.

The average value of ϕ between r and r_w is:

$$\phi_m = (\phi_r - \phi_w)\left(1 - \frac{1}{2\log\frac{r}{r_w}}\right) + \phi_w \quad \ldots\ldots\ldots\ldots (4)$$

The average pressure for a perfect gas will lie between the following limits:

$$P_m < \left[(P_r^2 - P_w^2)\left(1 - \frac{1}{2\log\frac{r}{r_w}}\right) + P_w^2\right]^{1/2} \quad \ldots\ldots\ldots\ldots (5)$$

$$P_m > (P_r - P_w)\left(1 - \frac{1}{2\log\frac{r}{r_w}}\right) + P_w \quad \ldots (6)$$

For conditions of interest in actual gas reservoirs the limiting values of (5) and (6) are practically identical. The simpler incompressible fluid average (6) may be used.

Setting $x = r/r_w$ and substituting (6) in (2):

$$W = \frac{\pi\, t\, r_w^2 f\, (P_r - P_w)}{2}\left(\frac{x^2}{\log x}\right). \quad (7)$$

$$\frac{dw}{dx} = \frac{\pi\, t\, r_w^2 f\, (P_r - P_w)}{2}\left(\frac{x}{\log x}\right)\left(2 - \frac{1}{\log x}\right). \quad (8)$$

If the well pressure is dropped to and maintained at P_w, from (3):

$$d\theta = \frac{\mu \log x}{\pi\, t\, k\, (P_r^2 - P_w^2)}\, dw \quad \ldots (9)$$

$$\theta = \frac{\mu r_w^2 f}{2k(Pr + P_w)}\left[2\int^x x\,dx - \int^x \frac{x\,dx}{\log x}\right]. \quad (10)$$

Taking the lower limit of integration such that time is zero when $r = r_w$:

$$\theta = \frac{\mu r_w^2 f}{2k\,(Pr + P_w)}\left(x^2 - E_i\,(2\log x)\right) \quad \ldots\ldots\ldots\ldots (11)$$

Residual terms of Euler constant and log 2 have been dropped as negligible. The expression $E_i(2\log x)$ is the exponential integral.

By another, possibly more direct, approach this expression becomes:

$$\theta = \frac{\mu f r^2}{2k(P_r + P_w)}\left(1 - \frac{1}{2\log\frac{r}{r_w}}\right). \quad (12)$$

Disregarding the correction term for the moment, the variations of time with the other variables is seen to be:

1. Inversely proportional to the permeability
2. Independent of the sand thickness
3. Directly proportional to the porosity
4. Practically independent of the rate of production

As an illustration of the time involved Table 1 has been calculated for a sand having the following characteristics:

porosity	20%
viscosity	.015 centipoise
permeability	.050 darcy
Reservoir pressure	300 atmos.
Flowing pressure	295 atmos.
Radius of Well	10 cm.

TABLE 1

r (feet)	Time
10	4.0 seconds
50	1.75 minutes
100	7.0 minutes
500	3.0 hours
1000	12.2 hours
5000	13.0 days
10,000	51.5 days

CONCLUSIONS

The great length of time which may be involved in transients may be calculated from the appropriate constants. Thus the Monroe gas field contains areas having transient time of the order of years. This produced the anomaly of a field effectively depleted in one portion but with virgin pressure in another even though both were connected.

Some attempts have been made to establish or disprove continuity of formation by the observance of interference effects between wells. Although this is theoretically possible and such interference effects have been observed the observational difficulties are formidable and the probable existence of complex transients further decreases the likelihood of an extensive application of this method.

The same conclusions, even more forcibly, apply to attempts to measure reservoir constants by transient observation. Although equations (2) and (11) contain both porosity and permeability in such fashion that, at least theoretically, they may be determined from field observation, it is unlikely that the permeability is ever sufficiently uniform to permit an evaluation of the

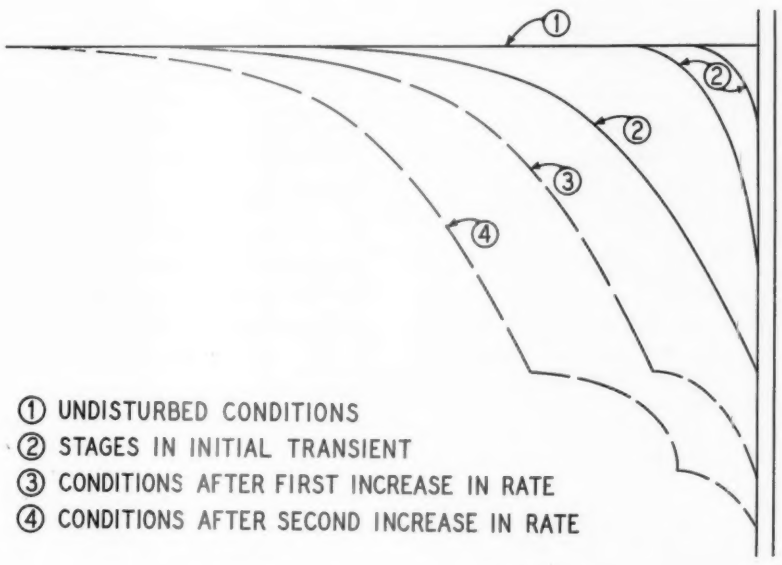

FIG. 2 — PRESSURE DISTRIBUTION IN RESERVOIR.

porosity to any usable degree of accuracy. However, a basic method very similar to this has been proposed for water reservoirs by Theis[1] and applied by Wenzel[2] and others.

Whether the transient phenomenon can be used or not its effects must be recognized: in particular its effects on the observations constituting back-pressure tests on gas wells. The basic difficulty arises from the fact that the velocity of propogation of each disturbance is practically independent of the intensity. The vicinity of a well soon becomes an area of complex disturbances. Although movement of gas is always toward the well the rate of movement is neither uniform nor uniformly distributed. Although the pressure decreases toward the well the time derivatives of pressure may have values differing in magnitude and sign. When more than one well is considered the complexity is compounded and even the direction of flow and of pressure gradients is not uniform. A field of moderate permeability and dimensions should, if closed in after producing for some time, show strange pressure behavior at many wells.

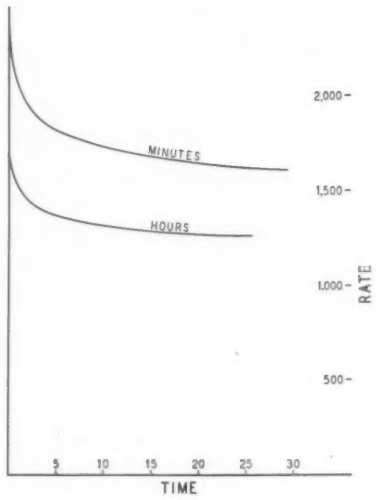

FIG. 3 — DECLINE IN RATE OF FLOW DURING INITIAL TRANSIENT.

As a result of these complex transients, pseudo-stabilization readily occurs and test values may easily be recorded which have no validity. In back-pressure testing it has long been noted that in many instances the test was affected by the "direction" of the test, i.e., whether conducted from low to high rates of flow or vice versa. The differences are readily explained by transient theory. ★ ★ ★

[1] American Geophysical Union, 1935, p.519
[2] American Geophysical Union, 1944, p.940

CAPILLARY PRESSURES – THEIR MEASUREMENT USING MERCURY AND THE CALCULATION OF PERMEABILITY THEREFROM

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ABSTRACT

An apparatus is described whereby capillary pressure curves for porous media may be determined by a technique that involves forcing mercury under pressure into the evacuated pores of solids. The data so obtained are compared with capillary pressure curves determined by the porous diaphragm method, and the advantages of the mercury injection method are stated.

Based upon a simplified working hypothesis, an equation is derived to show the relationship of the permeability of a porous medium to its porosity and capillary pressure curve, and experimental data are presented to support its validity.

A procedure is outlined whereby an estimate of the permeability of drill cuttings may be made with sufficient acuracy to meet most engineering requirements.

INTRODUCTION

The nature of capillary pressures and the role they play in reservoir behavior have been lucidly discussed by Levrett[1], Hassler, Brunner, and Deahl[2], and others. As a result of these publications the value of determining capillary pressure curves for cores has come to be generally recognized within the oil industry. While considerable attention has been directed toward the subject in an effort to provide a reliable method of estimating percentages of connate water,[3,4,5] it has been recognized that capillary pressure data may prove of value in other equally important applications.

This paper describes a method and procedure for determining capillary pressure curves for porous media wherein mercury is forced under pressure into the evacuated pores of the solids. The pressure-volume relationships obtained are reasonably similar to capillary pressure curves determined by the generally accepted porous diaphragm method. The advantages of the method lie in the rapidity with which the experimental data can be obtained and in the fact that small, irregularly shaped samples, e.g., drill cuttings, can be handled in the same manner as larger pieces of regular shape such as cores or permeability plugs.

Based upon a simplified working hypothesis, a theoretical equation will be derived which relates the capillary pressure curve to the porosity and permeability of a porous solid, and experimental data will be presented to support its validity. This relationship applied to capillary pressure data obtained for drill cuttings by the procedure described provides a means for predicting the permeability of drill cuttings.

METHODS FOR DETERMINING CAPILLARY PRESSURES

Several techniques have so far been employed in determining capillary pressure curves and these fall into two principal categories:

(1) Liquid is removed from, or imbibed by, the core through the medium of a high displacement pressure porous diaphragm[3,4,5,6].

(2) Liquid is removed from the core which is subjected to high centrifugal forces in a centrifuge[4,6].

There are, however, certain limitations inherent in both methods.

The greatest capillary pressure which can be observed by method (1), above, is determined by the maximum displacement pressure procurable in a permeable diaphragm which at the present time appears to be less than 100 psi. An even more serious limitation of the diaphragm method is imposed by the fact that several days may be required to reach saturation equilibrium at a given pressure; hence, the time required to obtain a well-defined curve may be measured in terms of weeks. Furthermore, to date, no suitable technique for handling relatively small, irregularly shaped pieces of rock, such as drill cuttings, has been reported and, therefore, measurements must be made, in general, on cores, or portions thereof.

The centrifuge method offers the distinct advantage over the porous diaphragm method of arriving at saturation equilibrium in a relatively short time by virtue of the elimination of the transfer medium for the liquid. The calculation of capillary pressures from centrifuge speeds is somewhat tedious[6], however, and the equipment required is fairly elaborate. While there exists the possibility that this method might be adaptable to the determination of the capillary pressures of cuttings, this particular ramification has not been investigated, as far as is known.

In view of the limitations of the two principal methods for determining capillary pressures, the apparatus described in the following sections has been devised in order that difficulties previously encountered might be circumvented.

MERCURY INJECTION METHOD FOR DETERMINING CAPILLARY PRESSURES

Theory

The methods described above for determining capillary pressures are characterized by the fact that one of the fluids present within the pore spaces of the solid is a liquid which "wets" the solid, i.e., the contact angle which the liquid forms against the solid is less than 90° as measured through that phase.

For these "wetting" liquids the action of surface forces is such that the fluid spontaneously fills the voids within the solid. These forces likewise oppose the withdrawal of the fluid from the pores of the solid.

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[1] References are given at the end of the paper.

There is, however, a second type of system which may be considered in the study of capillary pressures. This system involves the porous solid and a single "non-wetting" fluid (mercury) which forms a contact angle of greater than 90° against the solid. In this case the action of the surface forces involved opposes the entrance of the liquid into the solid and pressure must be applied to the liquid to cause penetration of the pores of the solid.

This type of system has been employed by Drake and Ritter[7] in studying the pore size distribution of catalysts, and the apparatus to be described below has been developed in order that similar techniques might be applied to materials exhibiting pore sizes of the order of that found in naturally occurring rock formations.

Apparatus and Procedure

An apparatus suitable for determining capillary pressures of porous media is shown in Fig. 1. The essential components of the apparatus are a mercury displacement pump A, a sample holder B, both shown in detail, and a manifold system C, shown schematically, wherein the gas pressure may be varied from small absolute values (high vacuum) to about 2000 psi. gauge.

The mercury pump consists of a piston-cylinder arrangement, the former being moved by means of an accurately machined screw, the pitch of which is such that one turn of the driving mechanism moves the piston through a distance sufficient to displace one cubic centimeter. The volume of liquid displaced from the pump is determined by successive readings of the scale D, and vernier E which is attached to the hub of the hand wheel.

The sample holder consists of two parts, both of which carry a lucite window, G, of frusto-conical shape which is cemented into the body of the holder and held rigidly in place by bushings. The displacement pump is connected to the sample holder and manifold by means of diametral conduits through the two lucite plugs. Reference marks, H, are incorporated in these conduits at about the midway point of the lucite windows and may be viewed through the openings in the supporting bushings.

The manifold is connected, as shown, to both a vacuum system and a high pressure (2000 psi) nitrogen bottle. To this manifold are also connected a manometer and pressure gauges suitable for measuring gas pressures ranging from a few millimeters of mercury, absolute, to 2000 psi, gauge.

In operation, one or more plugs drilled from a core, or a number of drill cuttings, which have been extracted and dried, are placed in the cavity, F, of the sample holder. The top portion of the sample holder is positioned and the two parts brought together by a make-up nut. A suitable gasket makes the seal pressure tight.

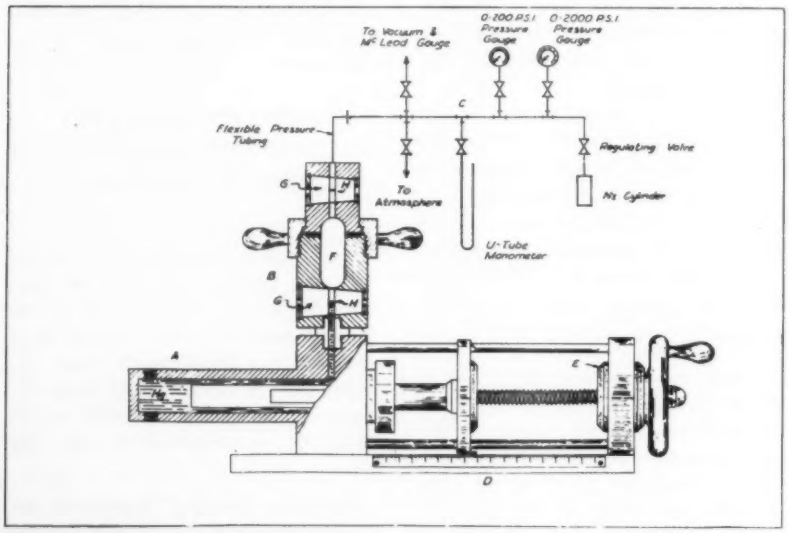


FIG. 1 — APPARATUS FOR DETERMINING MERCURY CAPILLARY PRESSURES

With the mercury level somewhat below the reference line of the lower lucite window, a vacuum is drawn on the system until an absolute pressure of 0.005 mm. of mercury, or less, is registered by the McLeod gauge. The mercury level is then accurately positioned at the lower reference mark by advancing the piston of the displacement pump. The scales attached to the volumetric pump are set at zero following which the piston is further advanced until the mercury meniscus reaches the reference mark in the top lucite window. At this point a scale reading is made which indicates the amount of mercury required to fill the cell with the sample in place. This quantity is subtracted from the known volume of the sample holder (between the reference marks) to provide a measure of the bulk volume of the sample under test.

The vacuum pump is isolated from the manifold and gas admitted to the system in increments, thereby increasing the pressure on the mercury surrounding the sample. The entrance of mercury into the pores of the core or cuttings is indicated by a recession of the mercury-gas interface from the upper reference line, and the degree of penetration is determined by advancing the displacement pump piston until the mercury meniscus returns to this reference mark.

The procedure of alternately building up the pressure to cause recession of the mercury meniscus and advancing the pump piston to return the meniscus to the reference mark, thereby determining the amount of mercury injected into the porous solid under various pressures, is repeated until the pressure of the nitrogen cylinder is reached.

A pressure-volume correction curve is established for the apparatus by carrying out a run as described above without a sample in the holder. The volume readings obtained when testing cores or cuttings are corrected by subtracting amounts as determined by this blank run at corresponding pressures.

The pressure on the mercury entering the sample is taken as the pressure in the gas phase plus a hydrostatic head due to the weight of the column of

mercury between the upper reference line and the midway point of the sample. This hydrostatic head may be determined by direct measurement.

Inasmuch as saturation equilibrium is reached very rapidly at any particular pressure, an entire curve may be determined in from 30 to 60 minutes. Temperature fluctuations of the system are ordinarily not sufficiently great during this time to require corrections for thermal expansion or contraction.

Experimental Results

In Figs. 2 to 8, inclusive, (Pages 44 and 45), mercury capillary pressure curves determined in the manner just described are compared with curves determined with water* and air using the porous diaphragm method. The air permeabilities and total porosities of the samples are shown on the graphs.

In comparing these curves it must be recalled that the magnitudes of the capillary pressures are proportional to the product of the surface tension of the liquid being used and the cosine of its angle of contact against the solid. While the surface tensions of the liquids involved can be measured with fair accuracy, the uncertainty in values of the contact angles makes it difficult to predict in advance the exact ratio which should exist between mercury and water/air capillary pressures at corresponding saturations. As a first approximation, however, the following values can be assumed:

Surface tension of water: 70 dynes per cm.

Surface tension of mercury: 480 dynes per cm.[7]

Contact angle of water against the solid: 0°

Contact angle of mercury against the solid: 140°[7]

The required ratio is then,

$$\frac{\text{(Mercury Capillary Pres.)}}{\text{(Water/Air Capillary Pres.)}} = \underset{\text{saturations}}{\text{corresponding}}$$

$$\frac{-(480)\ (\cos 140°)}{(70)\ (\cos 0°)} \approx 5.$$

It will be seen that the curves of Figs. 2 to 8 have been plotted on scales such that this approximate ratio of 5 to 1 is taken into account and hence they may be easily compared qualitatively by visual observation.

As evidenced by these curves, which are typical of those so far obtained, relatively close agreement has been found between mercury and water/air capillary pressure curves for the various types of formations studied and over the range of permeabilities and porosities encountered.

Fig. 9 (P.45) is included to show a capillary pressure curve over the entire saturation range (from 0% to 100%). With the apparatus just described it is possible to measure mercury capillary pressures of the order of 2000 psi. which corresponds approximately to a water/air capillary pressure of 400 psi. The apparatus could be adapted for measurements at higher pressure if this were deemed advisable.

The advantages of the mercury injection method over those previously used are that an entire curve of as many as twenty to thirty points may be determined in about an hour's time and small irregularly shaped pieces can be handled in the same manner as larger portions of regular shape. In addition, the range of capillary pressures that can be observed is considerably greater than for the porous diaphragm method.

CALCULATION OF PERMEABILITY FROM CAPILLARY PRESSURE CURVES

In reservoir analysis and production practice, the importance of that property of rock formations which is referred to as permeability has long been recognized by the exploitation engineer. The determination of air permeability has, for some time, been a routine core analysis test, but in order to obtain the required measurements for this determination, it is first necessary to procure a sample of regular shape and of appreciable dimensions. To accomplish this end, the expensive operation of coring is generally resorted to.

In the course of drilling, cuttings are usually available which, although too small to be suitable for permeability measurements, provide satisfactory samples with which to determine other important characteristics of the rock formation from which they were cut. An apparatus has been described in the preceding sections which enables the measurement of capillary pressure curves for cuttings. An equation will now be developed which provides a means for calculating the permeability of a porous medium from capillary pressure data. This, in turn, of course, makes possible the estimation of the permeability of drill cuttings.

Theory

The rate of flow Q/t, of a fluid of viscosity, μ, through a single cylindrical tube or capillary of length, L, and internal radius, R, is given by Poiseuille's equation:

$$\frac{Q}{t} = \frac{\pi R^4 P}{8\mu L}, \qquad \ldots\ldots\ldots (1)$$

wherein P is the pressure drop across the tube. Since the volume, V, of this capillary is $\pi R^2 L$, equation (1) may be written as,

$$\frac{Q}{t} = \frac{VR^2 P}{8\mu L^2}, \qquad \ldots\ldots\ldots (2)$$

The capillary pressure for this single tube, is given by the Pressure of Displacement Equation,

$$P_c = \frac{2\sigma \cos\theta}{R}, \qquad \ldots\ldots\ldots (3)$$

where P_c, the capillary pressure, is the minimum pressure required to displace a wetting liquid ($\theta < 90°$) from or inject a non-wetting liquid ($\theta > 90°$) into a capillary of radius R when the surface or interfacial tension at the interface is σ and the angle of contact which this interface forms with the solid of the capillary is θ.

Equation (3) indicates that capillary pressure is inversely proportional to pore radius and hence may be used as a measure of capillary size. Substituting equation (3) in (2) we have,

$$\frac{Q}{t} = \frac{(\sigma \cos\theta)^2 VP}{2\mu L^2 (P_c)^2} \qquad \ldots\ldots (4)$$

Consider now a system composed of a large number, N, of parallel, cylindrical capillaries of equal length but random radii, each tube being identical in all respects except internal area to the capillary under discussion above. The total rate of flow $(Q/t)_s$ through this system must be equivalent to the sum of the contributions made by each of the N single tubes or capillaries.

* The water used in all tests referred to in this paper contained 5 per cent by weight of sodium chloride.

The flow through each individual tube is given by equation (4); the total flow, therefore, may be represented as follows:

$$(Q/t)_s = \frac{(\sigma \cos \theta)^2 P}{2\mu L^2} \sum_{i=1}^{N} \frac{V_i}{(P_c)_i^2} \quad . \quad (5)$$

On the other hand, the rate of flow $(Q/t)_s$ through this same system of capillaries is also given by Darcy's Law:

$$(Q/t)_s = \frac{K A P}{\mu L} \quad , \qquad \ldots\ldots (6)$$

where K is the permeability of the system, L is the length of the tubes, A is the total cross-sectional area of the system, and P is the pressure differential causing flow.

By equating the right-hand members of the equations (5) and (6) the following is obtained:

$$K = \frac{(\sigma \cos \theta)^2}{2AL} \sum_{i=1}^{N} \frac{V_i}{(P_c)_i^2} \quad \ldots\ldots (7)$$

To simplify equation (7) the volume, V_i, of each capillary may be expressed as a percentage, S_i, of the total void volume, V_T, of the system, i.e.,

$$\frac{V_i}{V_T} \times 100 = S_i \quad .$$

Furthermore, since AL is the bulk volume of the system we may introduce the per cent porosity, f, where

$$f = \frac{V_T}{AL} \times 100 \quad ,$$

and equation (7) becomes

$$K = \frac{(\sigma \cos \theta)^2 f}{2 \times 10^4} \sum_{i=1}^{N} \frac{S_i}{(P_c)_i^2} \quad \ldots\ldots (8)$$

Equation (8) relates the permeability of a system of parallel cylindrical capillaries of equal lengths, but various radii, to the porosity of the system and to the capillary pressures and volumes of its component parts.

Equation (8) is derived for a porous medium composed of non-interconnected capillaries of circular cross-section and equal length. Certainly no such system obtains in naturally occurring rock formations. The path by which a fluid may travel through a rock is circuitous, for the pore spaces within these materials are usually interconnected to a greater or lesser degree. Furthermore, this path is neither uniform nor circular in cross-section. It is necessary, therefore, to modify equation (8) by introducing a so-called lithology factor, F, to account for differences between the flow in the hypothetical porous medium for which equation (8) was derived and that in naturally occurring rocks. Equation (8) becomes

$$K = \frac{F(\sigma \cos \theta)^2 f}{2 \times 10^4} \sum_{i=1}^{N} \frac{S_i}{(P_c)_i^2} \quad . \quad (9)$$

The amount of variation in the factor F (to be discussed below) for samples of equivalent and of different lithology will determine the practical utility of equation (9).

The evaluation of the quantity

$$\sum_{i=1}^{N} \frac{S_i}{(P_c)_i^2}$$

can best be presented by reference to Fig. 10, which shows a typical capillary pressure curve for a naturally occurring porous media such as a reservoir sandstone.

Consider the change in saturation, $\Delta\rho$, that occurs when the pressure is increased from $(P_c)_1$ to $(P_c)_2$. This change in saturation is a result of liquid either entering (non-wetting liquid) or receding from (wetting liquid) all pores having capillary pressures lying between $(P_c)_1$ and $(P_c)_2$. All pores in this interval may be treated as if they exhibited some intermediate average capillary pressure, $(Pc)_{av.}$, where,

$$(P_c)_1 \; (P_c)_{av.} \; \text{VI} \quad (P_c)_2 \quad .$$

If a number, r, of such intervals are chosen, and if n_j is the number of pores in the jth interval, then

$$\sum_{i=1}^{n_j} \frac{S_i}{(P_c)_i^2} = \left[\frac{\Delta\rho}{(P_c)_{av.}^2}\right]_j \quad .$$

Likewise,

$$\sum_{i=1}^{N} \frac{S_i}{(P_c)_i^2} = \sum_{j=1}^{r} \sum_{i=1}^{n_j} \frac{S_i}{(P_c)_i^2} =$$

$$\sum_{j=1}^{r} \left[\frac{\Delta\rho}{(P_c)_{av.}^2}\right]_j \quad .$$

and

$$\lim_{\substack{\Delta\rho \to 0 \\ r \to \infty}} \sum_{j=1}^{r} \left[\frac{\Delta\rho}{(P_c)_{av.}^2}\right]_j = \int_{\rho=0}^{\rho=100} \frac{d\rho}{(P_c)^2}$$

$$= \sum_{i=1}^{N} \frac{S_i}{(P_c)_i^2} \quad .$$

It is seen, therefore, that the quantity

$$\sum_{i=1}^{N} \frac{S_i}{(P_c)_i^2}$$ is equal to

the integral of the reciprocal of the square of the capillary pressure expressed as a function of per cent liquid saturation. Such a function is shown in Fig. 10 (P.45). This integral may be determined by planimetering or, more readily, by applying Simpson's Rule.

In the calculation of permeability by by equation (9) from mercury capillary pressure data a surface tension of 480 dynes per cm. and a contact angle of 140°7 are assumed. Equation (9) then reduces to

$$K = 0.66 F f \int_{\rho=0}^{\rho=100} \frac{d\rho}{(P_c)^2}, \qquad (9a)$$

where K is the permeability in millidarcies, f is per cent porosity, ρ is per cent of total pore space occupied by the liquid, and P_c the capillary pressure expressed in atmospheres.

Experimental Results

In an attempt to determine experimentally the utility of equation (9a), mercury capillary pressure curves have been obtained for numerous rock samples of two types of formations, the Upper Wilcox of Eocene age and the Paluxy of Cretaceous age. Samples of such size were used that their air permeabilities could be measured directly and these observed permeabilities were employed in determining the magnitude of, and the variation in, the factor F of equation (9a). The data obtained

TABLE 1

Observed Values of *F*

Sample No.	Factor *F*, Eq. (9a) Required to Make Calculated and Observed Permeabilities Identical	Permeability Calculated from Eq. (9a) Using an Average *F* of 0.216	Observed Air Permeability (md)
Upper Wilcox			
1	0.085	3.04	1.2
2(1)	0.122	21.2	12.0
3	0.168	17.3	13.4
4	0.149	53.5	36.9
5	0.200	61.9	57.4
6	0.165	91.6	70.3
7	0.257	92.3	110
8	0.256	97.5	116
9	0.191	163	144
10	0.107	680	336
11 (Fig. 6)	0.216	430	430
12	0.273	348	439
13	0.276	388	496
14(1)	0.185	902	772
15	0.282	816	1070
16	0.363	865	1459
Paluxy			
17	—	0.003	<0.1
18	—	0.10	<0.1
19	0.182	42.2	35.7
20	0.158	54.9	40.2
21	0.231	172	184
22	0.276	183	235
23	0.215	308	307
24	0.163	422	320
25	0.284	383	506
26	0.272	502	634
27 (Fig. 5)	0.338	734	1150
	Av. 0.216		

(1) "Cuttings"

with typical samples are recorded in Table I.

It will be seen in Table I that the factors *F* for the Upper Wilcox and Paluxy sands are of the same general order of magnitude. However, there is some indication that this factor may vary with permeability from a minimum of about 0.1 for samples of low permeability to about 0.4 for samples of high permeability.*

It may be possible, with the further accumulation of data, to establish values of the factor *F* for various permeability ranges. Likewise, it may be found that the factor *F* will be different for samples of widely divergent lithology** since the two formations studied in detail and reported here do not vary greatly in lithology. The Upper Wilcox is in general a poorly sorted sandstone while the Paluxy is a well sorted sandstone. The establishment of more precise values of *F*, however, will serve merely to increase the precision of the method for estimating permeabilities from capillary pressure data. For the moment, with the information at hand, quite satisfactory accuracy may be obtained by merely taking an arithmetical average of the factors *F* over the entire permeability range.

Table I gives observed air permeabilities together with permeabilities as calculated from equation (9a) using an average value of the factor *F* of 0.216. These values have been plotted in Fig. 11.

In Table I, samples 2 and 14 are designated as "cuttings". These samples were prepared by crushing cores of known air permeability to obtain a number of small pieces in approximately the size and shape of drill cuttings. Mercury capillary pressure curves were determined for these sets of "cuttings" in exactly the same manner as employed for the larger single pieces. It will be noted in Fig. 11 that the data for these "cuttings" fit the average line as well as the data for the cores.

The procedure for estimating the permeability of drill cuttings (or any porous medium, regardless of size or shape) consists of determining the capillary pressure curve by the method described above, calculating a permeability from the curve by means of equation (9) using a predetermined value of *F*, and then reading the corresponding air permeability from a plot such as that shown in Fig. 11. The spread of points of Fig. 11 is such as to indicate that the permeability so determined will be sufficiently accurate for most engineering requirements.

SUMMARY AND CONCLUSIONS

A method of determining capillary pressures for porous media wherein mercury is forced under pressure into the pores of the evacuated solid has been found to yield results which are reasonably similar to those obtained using the porous diaphragm technique. This method offers the following advantages over previously decribed procedures:

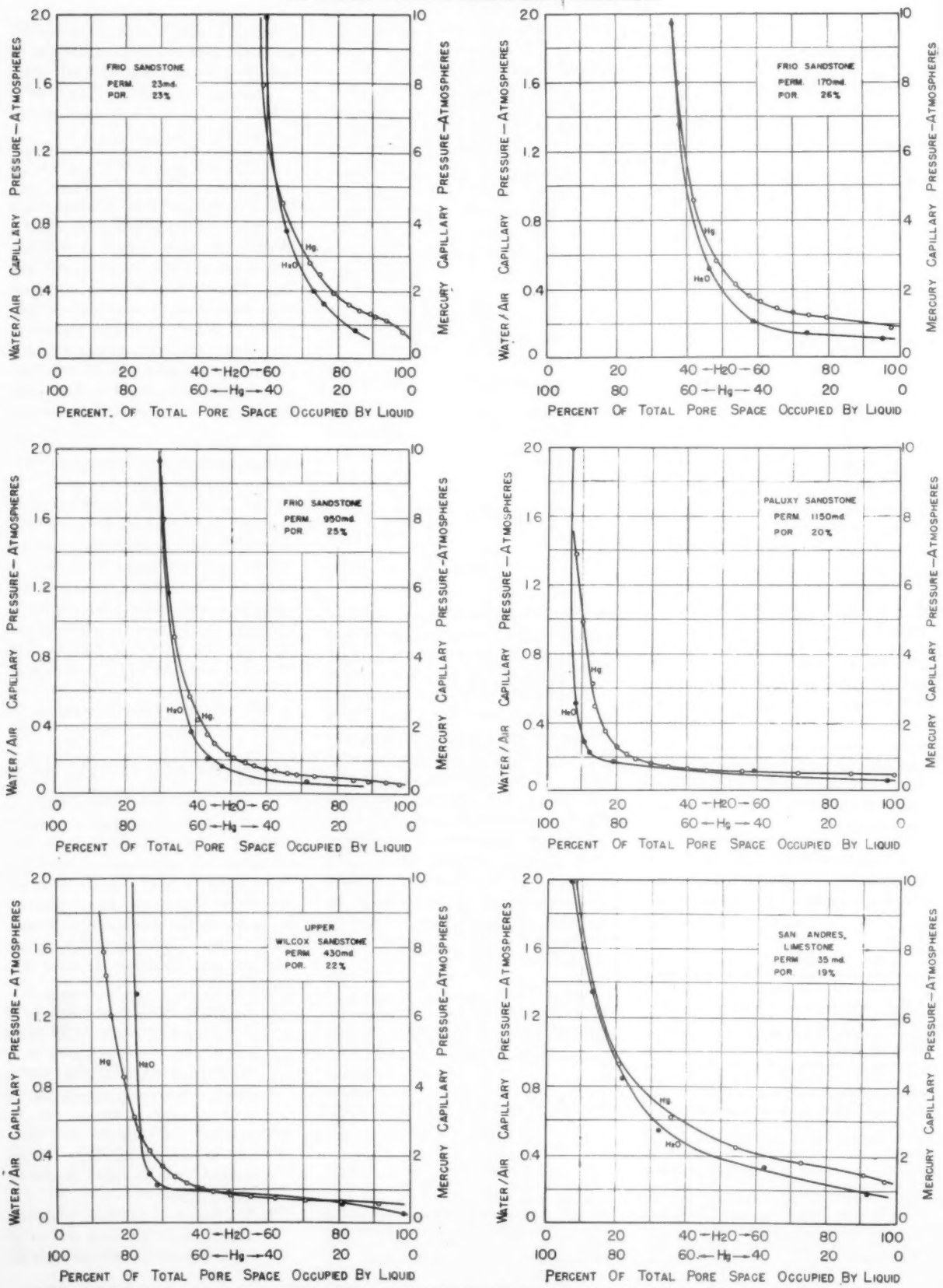
1. An entire capillary pressure curve consisting of as many as 20 to 30 points can be determined in a matter of hours rather than weeks.
2. Small, irregularly shaped pieces, such as drill cuttings, can be handled in exactly the same manner as larger, regularly shaped samples such as cores or permeability plugs.
3. The range of capillary pressures which can be observed is 5 to 10 times that of conventional methods.

* It may be shown both theoretically and experimentally[8] that for close-packed spheres of uniform size the length of the path by which a fluid may pass through such a system is $\pi/2$ times as great as the length of the pack. Since the length of the path enters into the denominator of equation (6) as a squared term, it can be shown that the factor $_F$ for this pack is $(2/\pi)^2$ or about 0.4. The difference between this value and those actually observed (0.1 to 0.4) may be due in part to inaccuracies in the assumptions of values for σ and θ, but is probably chiefly the result of the difference in pore structure between that of the ideal pack of uniform spheres and that of naturally occurring rock structures. It is interesting to note, however, that the observed values for $_F$ of natural rocks are of the same order of magnitude as, but somewhat less than, that which can be calculated for an ideal "sand" pack.

** While $_F$ values have been determined extensively for only the Upper Wilcox and Paluxy sandstones, it is interesting to note that the following values are obtained from the data presented in Figs. 2, 3, 4, 7, and 8.

Fig. No.	Formation	Factor, $_F$	Air Permeability (Md.)
2	Frio Sand	0.073	23
3	Frio Sand	0.271	170
4	Frio Sand	0.276	950
7	San Andres Lime	0.133	35
8	San Andres Lime	0.150	43

Although these values are in line with those reported in Table I for samples of comparable permeability, additional data must be obtained before it can be concluded that all four types of formations exhibit similar $_F$ factors.



FIGUES 2 THROUGH 7, L TO R, TOP, CENTER, BOTTOM — COMPARISON OF MERCURY AND WATER/AIR CAPILLARY PRESSURE CURVES.

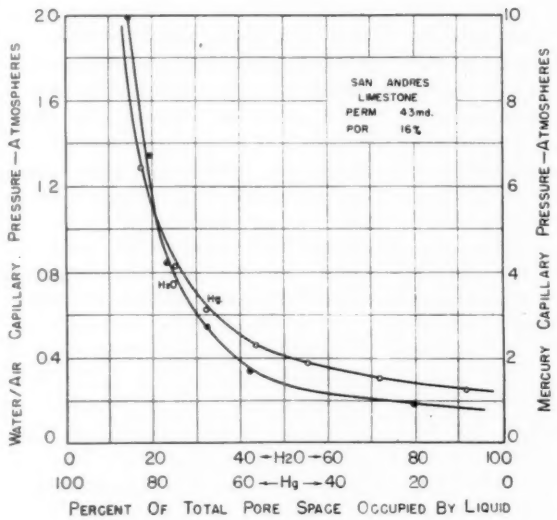


FIG. 8 – COMPARISON OF MERCURY AND WATER/AIR CAPILLARY PRESSURE CURVES

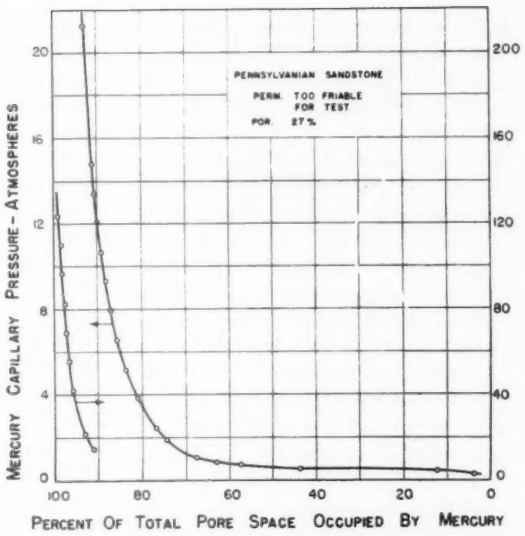

PENNSYLVANIAN SANDSTONE
PERM. TOO FRIABLE FOR TEST
POR. 27%
MERCURY CAPILLARY PRESSURE - ATMOSPHERES
PERCENT OF TOTAL PORE SPACE OCCUPIED BY MERCURY

FIG. 9 – MERCURY CAPILLARY PRESSURE CURVE OVER THE ENTIRE SATURATION RANGE

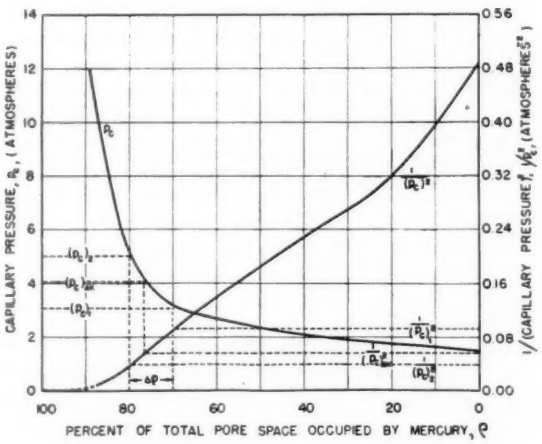

CAPILLARY PRESSURE, P_c, (ATMOSPHERES)
1/(CAPILLARY PRESSURE)^2, $1/P_c^2$, (ATMOSPHERES^{-2})
PERCENT OF TOTAL PORE SPACE OCCUPIED BY MERCURY, P

FIG. 10 – PERCENT SATURATION AS A FUNCTION OF CAPILLARY PRESSURE AND RECIPROCAL OF SQUARE CAPILLARY PRESSURE

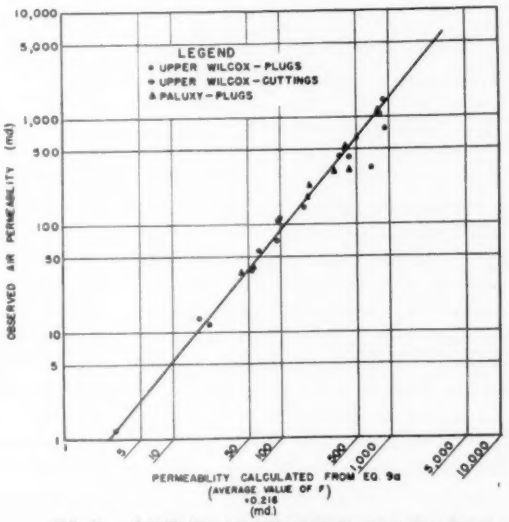

LEGEND
• UPPER WILCOX – PLUGS
○ UPPER WILCOX – CUTTINGS
▲ PALUXY – PLUGS
OBSERVED AIR PERMEABILITY (md)
PERMEABILITY CALCULATED FROM EQ. 9a (AVERAGE VALUE OF F) +0.216 (md.)

FIG. 11 – OBSERVED AIR PERMEABILITY AS A FUNCTION OF PERMEABILITY CALCULATED FROM EQUATION 9A.

An equation has been derived which indicates theoretically the relationship which should exist between the permeability of a porous medium and its capillary pressure curve. Experimental data have been presented to show that this equation provides a fairly reliable method of calculating permeability from capillary pressure data.

A combination of the method for measuring the capillary pressure curve of drill cuttings and the equation relating permeability to the capillary pressure curve so determined makes possible the estimation of the permeability of those cuttings.

ACKNOWLEDGMENT

The author wishes to express his appreciation for the aid and cooperation of Mr. G. E. Archie in the formulation of the problem, for the assistance rendered by Messrs. M. A. Westbrook and C. F. Blankenhorn in designing and assembling the apparatus, and for the many valuable suggestions offered by Mr. J. P. Murphy during the preparation of the manuscript.

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DISCUSSION

☆

By Walter Rose, Gulf Research and Development Company, Pittsburgh, Pa.

It is appropriate certainly to compliment Mr. Purcell on the interesting manner in which he has called attention to another laboratory method for measuring capillary pressure phenomena, and to another useful application for capillary pressure data. It appears that conventional methods for measurement have not been utilized fully to serve the purposes of routine laboratory core analysis because of the instrumentation and associated difficulties which have been encountered; and also it appears that the heretofore emphasized application for capillary pressure data to evaluate initial fluid phase distributions in virgin petroleum reservoirs can be discredited to some extent due to theoretical uncertainties. However, it is not to be expected that the results of Mr. Purcell's work immediately provide solutions for all the problems related to the evaluation and application of capillary pressure phenomena. This is because the data obtained by the mercury penetration method is not equivalent entirely to that obtained by conventional procedures, as perhaps implied by Purcell, in ways now to be discussed. Elsewhere it will be shown, however, that the data obtained by the mercury penetration method indeed lead to the other useful results suggested by Purcell.

It is to be assumed that when a difference in pressure is established at the interfaces of contact between immiscible fluids saturating the interstices of porous media, this capillary pressure (as an explicit function of fluid saturation and an implicit function of fluid distribution) is in effect a measure of the interstitial pore widths containing these interfaces of contact, assuming conditions of static equilibrium obtain. From this standpoint then it is apparent that Purcell's method and conventional methods of capillary pressure measurement all yield potentially the same kinds of data. To obtain the exact equivalence of these data by the various methods, however, requires that consideration be given to the well-known hysteretic possibilities, that the configurational character of the interstitial spaces not be variably affected by the method of measurement employed, and that the dynamic mechanism of wetting and non-wetting fluid flow (as static equilibruim is approached) be unrelated to the method of measurement employed. Presumably, the first requirement has been satisfied by Purcell's experimentation for he attempts comparison of data obtained only by the capillary drainage mechanism (i.e. where the invading non-wetting phase permits only drainage and no intermediate imbibition of the wetting phase) so that hysteretic uncertainties need not be considered. Regarding the second requirement, it is felt that only in the case of "inert" porous media will the character of the interstitial spaces be unrelated to the physico-chemical properties of the saturating fluids. As an example, the presence of interstitial surface clay coating in certain types of naturally occurring porous media will certainly result in a different pore structure when mercury and rarified gas are substituted for oil and brine as the saturating fluids, due to the dependence of the clay swelling effects on the nature of the fluids contacting the clays. Thus, even in conventional capillary pressure experimentation it has been recognized that use of reservoir-like fluids is to be preferred so that the data will truly reflect on the pore character representative of the natural reservoir condition. This refinement evidently cannot be employed in the use of Purcell's method. However, it is the inevitable disregard for the third requirement as above stated which most seriously limits the possibility of attaining equivalence between the results of Purcell's method and conventional methods, but which nonetheless leads to the potential usefulness for Purcell type experimentation as described in his paper. For it can be anticipated on theoretical grounds, and indeed it can be established from an examination of Purcell's data (c.f. Purcell's Figures 2 through 8), that "irreducible" minimum wetting phase saturations (reflecting on zero wetting phase relative permeability due to the attainment of pendular configurations) will not be a result of the mercury penetration method, since this procedure involves a compression rather than a flow of the wetting phase as desaturation occurs. It is evident then that the data reported by Purcell reflect principally on a complete distribution of pore radii, as originally advanced by Ritter and Drake (c.f. Reference 7 of Purcell's paper), providing information not directly derivable from conventional capillary pressure curves and leading to a method for approximating permeabilities and lithology characteristics of porous media. However, it must be emphasized that exact equivalence between conventional capillary pressure data and that obtained by the mercury penetration method is not to be expected as a common result.

The interesting feature about Purcell's equation for permeability is that it can be arrived at by several processes, leading to a more complete interpretation of the lithology factor, F. For instance, in a recent paper (not yet generally available)* an expression for permeability is given as:

$$k = \frac{\left[\lim_{\rho_w \to 1} j(\rho_w)\right]^2 \left[\sigma \cos\theta\right]^2 f}{P_D^2 \times 10^2} \qquad \text{Eq. (1)}$$

where ρ_w is the fractional wetting phase saturation, $j(\rho_w)$ is Leverett's capillary pressure function, P_D is the displacement pressure as commonly defined, and where the other notation follows that as employed by Purcell. In this cited reference it is shown that the limiting (minimum) value for the capil-

*Walter Rose and W. A. Bruce, "Evaluation of Capillary Character in Petroleum Reservoir Rock", *Jnl. of Petr. Tech.*, in press, (1949).

lary pressure function can be identified with the "rock" textural constant, t, appearing in the Kozeny equation for streamline fluid flow through porous media, as:

$$\lim_{\rho_w \to 1} j(\rho_w) = \left(\frac{1}{t}\right)^{1/2} \qquad \text{Eq.(2)}$$

Now, it is observed that the constant, t, as used in Eq.(2) refers to its maximum value, which has been established as being greater than 5 (and sometimes, for instance, as great as 500) as related to the various types of unconsolidated and consolidated porous media encountered in natural reservoir rock. This implies that Purcell's lithology factor generally will be less than 0.4, as indeed predicted and observed, for it is seen on combination of Eq.(1) above and Purcell's Eq.(9) or (9a) that:

$$\frac{F}{2} > \left(\lim_{\rho_w \to 1} j(\rho_w)\right)^2, \qquad \text{Eq.(3)}$$

since:

$$\int_0^1 \frac{d\rho}{P_c^2} < \frac{1}{P_D^2}. \qquad \text{Eq.(4)}$$

Moreover, it can be shown from these equations that the lithology factor, F, is defined fundamentally as:

$$F = \frac{2}{\int_0^1 \frac{d\rho}{j(\rho_w)^2}} = \frac{2}{t_{min}}. \qquad \text{Eq.(5)}$$

The above considerations imply that in texturally similar porous media the lithology factor, F, and the limiting value of the j function will be related to each other by some constant factor characteristic of the media, and that in texturally dissimilar media a rough proportionality will still obtain between these parameters. This is clearly shown by Figure 1, constructed from Purcell's data where F has been plotted versus $\lim_{\rho_w \to 1} j(\rho_w)$. It would appear, therefore, that Eq.(1) above has the same sort of validity and usefulness as Purcell's Eq.(9a), and its use is to be preferred since from the experimentation standpoint it is easier to evaluate. For only the initial segment of the capillary pressure curve need be measured (actually, only the displacement pressure need be measured) to solve Eq.(1) and to provide values reflecting on lithology or permeability characters of porous media equivalent to those obtained by Purcell. In this connection, a plot of F versus the logarithm of the corresponding permeability value is also given in Figure 1 and the linearity obtained by this plot suggests that in the classification of texturally dissimilar porous media a knowledge of permeability alone suffices sometimes to predict qualitatively lithological differences.

Figure 2 shows the results of some experimentation conducted recently to verify that the mercury penetration method of capillary pressure measurement would yield data equivalent to that obtained by conventional methods for inert porous media. Thus, Curve A of Figure 2 shows the capillary retention replot of the original Ritter and Drake data characterizing pyrex fritted glass media. Curve B is a similar plot of data obtained on other fritted glass media by the conventional capillary pressure technique, and the close conformance between these two curves can be taken as evidence that both methods have provided a measurement of the same phenomena, at least at the saturation levels where the wetting phase is continuous throughout the interstitial spaces (i.e. at saturations greater than those obtaining when the wetting phase configuration is pendular). These results are offered to support further the validity of the experimentation described by Purcell, for it is regarded that Purcell's technique for laboratory measurement must have high order accuracy and precision. This is shown also by the replot of the Frio core data as Curves C and D in Figure 2 from Purcell's Figures 3 and 4, since essentially the same capillary retention curve has been obtained for these two cores of widely different permeability. For when capillary pressure data yield the same capillary retention plot for different porous media, a condition of textural similarity between these media

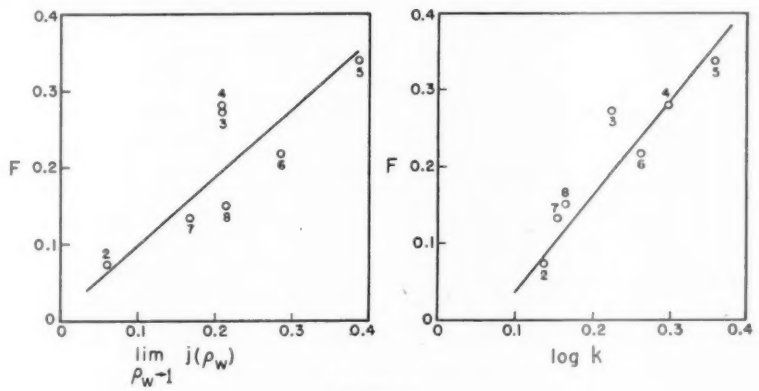

FIGURE 1

CORRELATION BETWEEN LITHOLOGY FACTOR, F, AND THE LIMITING VALUE FOR THE CAPILLARY PRESSURE FUNCTION, j(ρw), (C.F. LEFT DIAGRAM), OR THE LOGARITHM OF PERMEABILITY, LOG K, (C.F. RIGHT DIAGRAM). NUMBERS ASSOCIATE DATA POINTS WITH PURCELL'S FIGURE NUMBERS.

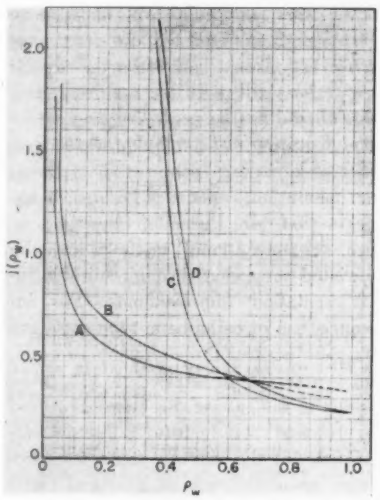

FIGURE 2

CAPILLARY RETENTION CURVES

CURVE A IS A PLOT OF THE RITTER AND DRAKE DATA.

CURVE B IS A PLOT OF DATA CONVENTIONALLY OBTAINED ON POROUS MEDIA TEXTURALLY SIMILAR TO THAT USED BY RITTER AND DRAKE.

CURVE C IS A REPLOT OF PURCELL'S FIG. 3.

CURVE D IS A REPLOT OF PURCELL'S FIG. 4.

is implied, as already was established in the case of the Frio cores by the observed approximate equivalence of the measured lithology factor.*

To conclude, it is apparent that Mr. Purcell, in applying his method for capillary pressure evaluation, has accomplished probably as much as will be forthcoming from experimentation of this sort. That is, he has developed suitably a rapid and precise method to make valid measurements of capillary pressure on small rock fragments reflecting on the permeability and the lithological character of porous media. Such data undoubtedly will be found to be useful for correlation purposes in the interpretation of the results of other core analysis experimentation. However, it is noted that for some purposes at least conventional experimentation still will be required, and this should not be neglected because of the features of simplicity associated with the mercury penetration type experimentation, especially because it appears that Mr. Purcell's objections to use of conventional methods can be obviated somewhat through suitable instrumentation improvements. For instance, use of cellophane type capillary barriers permits measurements of capillary pressure in excess of 300 p.s.i., which is well above the values required to produce "irreducible" minimum saturations of the wetting phase in petroleum reservoir rock of practical interest. Also, it is noted that the equilibrium values of saturation can be obtained by extrapolation of rate of displacement data, thereby decreasing the time required for conventional laboratory experimentation. Finally, it is noted that the recently proposed "multi-core" procedure for capillary pressure evaluation (c.f. Rose and Bruce paper, loc. cit.) has a potential use for the study of small core fragments similar to that characterizing Purcell's method of evaluation. In this connection, however, it must be realized that no method presently described in the literature will provide satisfactory capillary pressure data in those instances where the core fragments are so small that their total bulk surface area approaches the total interstitial surface area, thereby imposing a lower limit on these possibilities.

The consideration presented in this discussion have been directed to bear on the significance of the results of Mr. Purcell's excellent paper. It is to be recognized, however, that Mr. Purcell's paper, independent of these considerations, is a most valuable contribution to the literature, and the author is to be congratulated for his developments which contribute so significantly to our knowledge of capillary pressure phenomena.

Author's reply to Mr. Walter Rose:

It is indeed gratifying that Mr. Rose, through his discussion, has provided a link between the theoretical approach to the problem which is exemplified by his recent paper entitled "Theoretical Generalizations Leading to the Evaluation of Relative Permeability"† and the experimental approach of the author. It is believed that through a close intermeshing of these two general types of investigation our knowledge of capillary phenomena should increase substantially in the future.

Mr. Rose has very aptly pointed out certain conditions which must be satisfied if exact equivalence between mercury capillary pressures and those obtained by other means is to be obtained; likewise he has indicated that all of these conditions are not necessarily fulfilled. It would seem appropriate, therefore, to state that the author does not intend to imply, as indicated by Mr. Rose, that the mercury penetration method is exactly equivalent to conventional procedures but instead has chosen to show experimentally (as evidenced by Figures 2 to 8, inc.) that for the various types of formations studied and over the range of permeabilities and porosities encountered a reasonable similarity exists between mercury and water/air capillary pressures. In the paper no conclusions are drawn from the comparison tests other than the one of similarity between the two types of curves and this same conclusion has been obtained by Mr. Rose for his fritted glass plates. Furthermore, it should be pointed out that only one application of capillary pressure data, namely that of estimating permeability, is discussed.

Mr. Rose's confirmation of equation 9 by the derivation outlined in his discussion adds materially to the subject. The calculation of permeability from but a single point of the capillary pressure curve, namely the displacement pressure, should perhaps be used with caution, although it must be admitted indications are that the results so obtained would compare favorably with those obtained by an integration of the entire curve. In this connection, it might be pointed out that an accurate determination of the displacement pressure is exceedingly difficult by means other than mercury penetration.

It is stated in the discussion that difficulties usually encountered in conventional methods of determining capillary pressures, can be alleviated by suitable instrumentation. While it is apparent that the range of pressures can be extended through the use of cellophane membranes, this may be accomplished, perhaps, only through the aggravation of a second difficulty, namely that of the length of the time involved. Yuster** has recently stated that the extrapolation method of estimating equilibrium saturations from rates of displacement data gave accurate results in only about 25 per cent of the tests for which it was employed; hence, it may be concluded that this method of reducing the time involved in conventional tests should be used with reservation. It is to be hoped that the paper of Rose and Bruce referred to in the discussion will soon be made generally available for it is believed that any method of determining capillary pressure curves for cuttings will find immediate application. ★ ★ ★

* Note, from Curves C and D of Figure 2 the validity of the definition presented as Eq. (5) above is readily verified.

† *Jnl. of Petr. Tech.*, in press (1949).

** Producer's Monthly, December 1948, p. 24.

T.P. 2546

OUTLINE OF WEATHER AND WAVE FORECASTING TECHNIQUES

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INTRODUCTION

Oil operators engaged in drilling on the Continental Shelf of Louisiana and Texas are in agreement that adverse weather and wave action are two of the greatest hazards to the safety and efficiency of their work. It was anticipated when the offshore operations commenced that such would be the case, and experience to date has verified this assumption. Because atmospheric conditions and wave action involve tremendous amounts of energy it is highly unlikely that it will be possible to control any but the most localized weather and wave phenomena within the foreseeable future. Thus, as long as the offshore operations involve the movement of small craft and barges over exposed waters, and the transfer of personnel and heavy equipment from these craft to either fixed structures or larger craft at close quarters, the weather and wave problem will remain.

Taking into consideration the persistence of the wave and weather problem and the improbability of achieving a direct solution, the Humble Oil & Refining Company, in planning its offshore campaign investigated the possibility of forecasting wave and weather conditions in order to provide warnings of dangerous conditions and increase efficiency in day-to-day planning of work. It was recognized that predictions of wave and weather conditions based on meteorology and oceanography, both geophysical sciences, are not 100 per cent accurate and application of forecasts in the offshore work was dependent on whether they provided information which was sufficiently greater in accuracy than the layman's guess to be worth the expenditure involved.

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During World War II, meteorology and oceanography were used with success in reducing danger resulting from environmental conditions and increasing efficiency of operations exposed to the elements. This success was partially the result of improvement in the scientific techniques involved and the procurement and distribution of observational data, and partially due to the large scope of the military operations which meant that a reduction of losses of a relatively small percentage of the total cost amounted to a large figure expressed in terms of dollars. Since the offshore drilling involves an extremely large financial investment, it was considered that the experience of the Armed Services in successfully employing meteorology and oceanography might be duplicated in the oil industry. In addition, the oil industry's successful experience in utilizing seismology, geology, and terrestrial magnetism; all geophysical sciences, indicated that meteorology and oceanography, also of the family of geophysical sciences and sharing their scientific assets and liabilities, might be profitably put to use.

Since the immediate problem involving the sciences of meteorology and oceanography in the offshore campaign is wave action, a program was inaugurated within the Humble Oil & Refining Company during June 1947, the purpose of which was to ascertain the applicability and limitations of wave forecasting in the offshore campaign. A summary of the effective wave forecasting techniques developed during the war was prepared in the form of a forecasting manual for the Continental Shelf off Grand Isle, Louisiana, by Bates and Glenn. After completion of this manual, experimental forecasts were prepared daily over a two-month period by Graham and Thompson to determine the accuracy of the forecasts. It was considered that the accuracy of the experimental forecasts justified a more extensive test under actual operating conditions in the offshore work and the firm of A. H. Glenn and Associates was set up under the sponsorship of the Humble Oil & Refining Company to work with the Humble Grand Isle District in providing forecasts of wave and weather conditions over a one-year period. This paper discusses the service now provided to the Grand Isle District, its applicability and limitations.

TYPE OF FORECASTS REQUIRED

It was apparent before the commencemence of the forecasting service that a specialized type of forecast was required. Many of the weather elements of interest to the general public, such as rain and temperature, are of minor concern to offshore operators. On the other hand, such elements as wave height and wind speed and direction are of great concern in the offshore operations since variations in wave height of a few feet in the critical range divide safe from hazardous working conditions. To be of utility, a forecasting service for the offshore work must provide detailed forecasts of the elements which affect the operation. With this in mind, it was decided that forecasts would include the following information: average wave heights to the nearest foot, wind speeds within a range of approximately 5 miles per hour, and wind directions within 22½ degrees. Since the procedure for forecasting these elements involves thorough analysis of weather data, it was decided to include a generalized forecast of weather conditions such as rain and cloud cover, although these are of secondary importance.

These forecasts have been prepared twice daily for periods of 24 and 48 hours in advance since the inauguration of the forecasting service. The 48-hour forecast is prepared with the understanding that the accuracy of this forecast during rapid changes of weather conditions is expected to be low. It was decided that revised forecasts would be issued on the basis of more recent data whenever an appreciable change in conditions was expected that had not been predicted in the routine forecasts.

FACILITIES NECESSARY TO PROVIDE WAVE AND WEATHER FORECASTS

Before discussing specific forecast procedure, the facilities which must be available to the meteorologist before a weather service can be provided will be outlined. This is necessary in order to explain the problems of providing a weather service in the coastal areas of Louisiana and Texas and also to indicate what in general are the meteorologist's tools in preparing a forecast. There is considerable misinformation circulated concerning the science of meteorology. This is partially the result of the publicity given a number of "quacks" and partially because the two theoretical sciences on which meteorology is based, thermodynamics and hydrodynamics, are somewhat abstract in comparison to other physical sciences which have obvious applications in machines in everyday use.

The first requirement of the meteorologist is a source of up-to-the-minute weather data which permits the construction of a quantitative three-dimensional representation of the atmosphere within a radius of one to two thousand miles from the point for which short range forecasts are to be made. These data are provided by the U. S. Weather Bureau. The Weather Bureau makes observations of weather conditions at a large number of meterological stations throughout the United States and in certain locations outside the continental limits. Such observations are also made by the meteorological services of other nations and these are communicated rapidly throughout the world. There are three types of standard meteorological observations: surface, winds aloft, and radiosonde observations. Surface observations are made throughout the world at land stations and on certain ships simultaneously four times daily. They are standardized by international agreement and include data on cloud cover, winds, pressure, temperature, humidity, visibility, precipitation and a number of other elements. Winds aloft observations in the United States and the Gulf-Caribbean area are also made four times daily by tracking the rise of a free balloon into the upper atmosphere either visually by use of a theodolite or by tracking a radar target suspended from the balloon. Radiosonde observations provide a determination of temperature, humidity, and pressure in the upper atmosphere. The radiosonde unit consists of a small radio transmitter the signal of which is modulated by pressure, temperature, and humidity sensitive elements. The unit rises through the atmosphere suspended from a free balloon, and a continuous recording of the three meteorological elements is received at the ground station. Radiosonde observations are made simultaneously at about 60 stations in the United States and Gulf-Caribbean regions. The surface, winds aloft, and radiosonde observational data are encoded and placed shortly after their procurement on U. S. Weather Bureau teletype circuits which make them immediately available to those with receiving services on this teletype circuit.

By the use of these data it is possible to construct charts for various levels from the surface to 50,000 feet in altitude which give the distribution of temperature, pressure, and moisture at each level. These charts provide the meteorologist with a three-dimensional reconstruction of the atmosphere around his locality within a few hours after the time the observations were made. The problem in forecasting is to extrapolate from the past sequence of weather conditions the future movements of and the energy transformations in the atmosphere which account for variations in weather conditions.

The second requirement of the meteorologist is accurate, routine, quantative observations of the weather conditions at the locations for which forecasts are made. In any particular locality the effect upon atmospheric conditions of irregularities in topography, the configuration of land and water areas, the differential cooling and heating of land areas and water areas by night and day, and the variation of normal surface temperatures must be considered before accurate forecasting is possible. In many areas of the country, forecasts for specific locations such as cities and airports have been made for many years and the so-called local effects are distinguished from the large scale changes in weather conditions have been determined. Such is not the case for the preponderance of the coastal areas of Louisiana and Texas. Thus, at the present time it is necessary to determine the local effects on the large scale atmospheric conditions in the coastal areas.

Accurate instrumental observations are also necessary to obtain an objective evaluation of the accuracy of the forecasts. An analogy may be drawn between the meteorologist's need for local observations at his forecast location and the geologist's need for samples of well cuttings in order to verify his predictions concerning location of oil deposits and improve future predictions. The geologist can state in broad terms the characteristics of the subsurface strata and whether there is likelihood of oil bearing strata in a given geographical zone. The accuracy of predictions of the existence of recoverable oil deposits at a specific location would be extremely low, however, if he had to depend entirely upon such generalized information. If the petroleum geologist did not have available accurate data concerning conditions within a restricted locality he would not be able to discover small scale features of the local geology which are all important in locating commercial production areas. The meteorologist's problem is identical. A forecast may be excellent from the standpoint of large scale features but if the local effects are not properly evaluated, the forecast may be utterly useless in practical application. Thus, the second requirement of the meteorologist is accurate observations made at the locality for which he is forecasting.

The third requirement in maintaining a forecasting service is rapid and reliable communcations. In most parts of the country this is no problem, but

unfortunately in the coastal areas where offshore operations are now progressing, communications are a major problem. For example, in providing forecasts for the Humble Grand Isle District it would be preferable to set up the forecasting office in the district office. However, there are no teletype line facilities to the south of New Orleans which would permit the installation of receiving drops on the Weather Bureau teletype circuits in the Grand Isle District office. This is typical of communications facilities over most of the Louisiana and Texas coasts. It is necessary, therefore, to establish the main forecasting office in New Orleans, which is serviced by Weather Bureau facilities, and depend upon radio or telephone communication of the forecasts and observations between the forecasting office and the center of offshore operations. At the present time public communications in most of the coastal areas of Louisiana and Texas are unreliable, crowded, or non-existent. This places a severe handicap on the success of a forecasting service because there is nothing more useless than a forecast received after the predicted weather has already occurred.

FORECASTING PROCEDURES

The ocean waves which are observed visually day after day are generated by the stress of the wind on the ocean surface. These waves may be subdivided into two types, wind waves and swell. Wind waves are those generated by the local wind. These waves are short and choppy; they increase rapidly in height when the wind increases and decrease rapidly when it decreases. Swell, sometimes called ground swell, consists of long, even, "rolling" waves. Swell is the end product after wind waves have moved away from the area in which they were generated. The movement of the wave energy through the water is such that the period and the wave length of the swell increases as it moves away from the generating area, accounting for the smooth regular characteristics of these waves. Swell may be observed at a location when calm wind conditions obtain locally. The appearance of the sea surface is the result of the local wind waves superimposed on the one or more swell wave trains which may be present.

In order to forecast wind wave conditions, it is first necessary to forecast the winds which will generate the waves, and second determine the characteristics of the waves produced by this wind. The wind conditions are predicted using meteorological charts and these predictions are subject to the errors of meteorological forecasting. The relationship between wind and wave conditions was developed for forecasting purposes during the war by a number of oceanographic research groups of which the work of Sverdrup and Munk at the Scripps Institution of Oceanography was outstanding. The height of ocean wind waves are now known to be determined by the speed of the surface wind; the distance over which it blows, known as the fetch; and the elapsed time during which the wind blows over the fetch, known as the duration. When the wind speed, fetch, and duration are determined, the wave height, period, direction of movement, and speed of movement can be ascertained. This process has been simplified by the use of graphs developed by Sverdrup and Munk.

To prepare forecasts of swell conditions, all the wind wave generating areas in the Gulf are considered as to the possibility of wind waves emerging from the leeward end of the fetch moving as swell to the offshore locations. The procedure employed in determining the decrease in height of the swell waves and the travel time of the swell wave train from its generating area to the offshore location has also been simplified to a rapid graphical technique.

Either wind waves or swell moving from deep into shallow water, or into areas where pronounced currents are present, undergo transformations as to direction of movement, height, and wave length and these factors must be considered in preparing the forecast. Forecasts of wave heights are prepared for specific locations, not for areas. Sometimes a group of off-shore rigs will have nearly similar characteristics as far as wave conditions are concerned, but this is not usually the case. In general, there will be differences in depth of water, bottom topography, exposure to open sea, length of fetch for offshore winds, and currents which result in variations in wave height from one rig location to another.

While strong winds and resulting high waves occur in a variety of meteorological situations, there are a number of weather phenomena of typical characteristics which occur repeatedly in the coastal areas of Louisiana and Texas causing high winds and waves for which a more or less standardized forecasting procedure has been developed. Discussion of the forecast procedure for such typical weather phenomena which affect the offshore work; northers, line squalls, hurricanes, may provide a more detailed explanation of the service being provided the Grand Isle District than can be ascertained from the preceding generalized discussion.

NORTHERS

During the period extending roughly from November to March the Gulf Coast area is subject to northers. Northers, known as polar outbreaks by the meteorologist, consist of a rapid southward flow of cold air in the low levels of the atmosphere. Where offshore locations are within 10 to 15 miles of the shore, the northwesterly winds immediately following the onset of the norther will rarely produce high waves even though wind speeds of 50 to 60 miles per hour obtain. However, the northers are frequently preceded by 20 to 25 mile per hour, southerly winds which over their long fetch across the Gulf have produced waves of the order of 10 to 15 feet in height moving from the south. The danger of the norther consists partially in the possibility of boats, ships, and barges moored adjacent to drilling platforms in such a position as to be braced against the southerly winds and waves to be suddenly subjected to action of strong northerly winds and choppy wind waves with little advance warning. The wind shift from south to north is likely to occur during a period of a few minutes with accompanying gusty winds and heavy rain showers. Ramming of the drilling platforms by the floating vessels is a possibility under these conditions. In addition to the dangers accompanying the onset of the norther, there is usually a gradual wind shift from northwesterly to northeasterly after the onset of the norther. The northeasterly winds are capable of raising considerably higher waves than the

northwest winds since they blow more nearly parallel to the coast and provide longer fetches for the generation of waves.

The forecasting for northers consists of a warning of 24 hours or more that a norther is moving towards the Gulf over the Great Plains, and a short range warning approximately 6 hours in advance of the movement of the norther to the rig locations. The latter short range warning can be supplemented by a 1- to 2-hour warning accurate within 30 minutes by use of radar. Radar is a very effective aid in forecasting weather conditions accompanied by rain cloud formations extending to high altitudes. Its use is described later under techniques utilized in forecasting line squalls. The long range warning of the norther is provided by analysis of the surface weather map based on weather observations made every 6 hours. The short range warning is provided by weather observations made every hour or at times of significant weather changes. For example, up-to-the-minute weather observations made at Biloxi, New Orleans, Baton Rouge, Lafayette, Lake Charles and Beaumont will permit the short range warnings for northers arriving along the Louisiana coast.

LINE SQUALLS

Line squalls are a common weather feature of the Louisiana coastal area, occurring four to five times per month with considerable severity in the spring months. Isolated squalls occur with much greater frequency but with less severity during the summer months. The line squall consists of a bank or cumulonimbus (thunderheads) clouds oriented along a northeast-southwest line. The line squall moves in a southerly direction approximately normal to its axis and is accompanied by strong, gusty winds, from a northerly or westerly direction; heavy rain; and lighting. During the spring months line squalls may be extremely hazardous. A severe line squall which occurred in the Grand Isle area on June 9 caused an increase of winds to 55 miles per hour with gusts to 75 miles per hour within a period of one-half hour. The moisture distribution and the wind conditions aloft which favor a development of line squalls are recognizable from standard meteorological charts so that an initial warning of the likelihood of a line squall can frequently be made 6 to 8 hours in advance.

The short range warning of the movement of a line squall into the offshore area is made by utilizing hourly weather reports from stations to the north which have already been passed by the squall and by use of radar. The clouds associated with the squall ascend vertically to an altitude between 15,000 and 40,000 feet and contain large water drops which reflect a radar signal. Thus, a clearly defined image delineating the rain areas of the line squall may be observed moving across a PPI radar scope. By plotting successive positions of the squall on the scope and extrapolating the movement, the arrival time of the squall can be determined within 15 to 20 minutes and the strength of the gusty winds can be estimated from reports from U. S. Weather Bureau stations previously affected by the squall. If no such reports are available, the gusty surface winds can be estimated from wind conditions aloft.

In general, the short duration of the line squall precludes the formation of high waves; however, wave heights of 5 to 6 feet have been measured during a squall passage. Such waves are accompanied by winds sufficiently strong to break a barge from its mooring and cause damage to the floating equipment and drilling platforms unless proper precautions have been taken in advance. The high, gusty winds acompanying squalls can also inflict damage to the the drilling and production equipment on the drilling platforms. Such items as drill pipe or tubing standing in the derrick can dangerously reduce its safe wind-loading characteristics. The pipe and the derrick can also be damaged by the pipe being blown around in the derrick if not properly tied down. The one-to-two-hour advance knowledge of the imminence of these severe squalls, which can be provided by the technique outlined above, is usually sufficient to take the precautions required for these severe blows of short duration.

HURRICANES

By far the most spectacular and dangerous phenomenon affecting offshore drilling and production operations is the hurricane. Extremely high waves are possible during hurricane conditions depending mainly on the depth of water where the operations are under way. On the basis of past hurricanes that have occurred along the Gulf Coast, the maximum wave height to be expected would be about 32 feet in water from 40 to 100 feet in depth; 24 feet in water 30 feet in depth; 15 feet in 20 feet of water; and 8 feet in water 10 feet deep. In anticipation of hurricane conditions it is usually necessary to secure drilling and production operations and evacuate personnel to safe points ashore. Considerable time can be consumed in preparing for evacuation and transporting personnel to safety. Obviously, it is important to receive hurricane warnings as far in advance of the storm as possible. Even before the storm itself moves into an area, swell which extends well out in front of the storm center can produce sea conditions which make any type of hurricane mooring arrangement difficult to accomplish unless begun in ample time.

Hurricanes consist of a counterclockwise revolving vortex of warm, moisture-laden tropical air 20,000 to 40,000 feet deep. There are no successful techniques yet devised for predicting the movement of hurricanes for long periods in advance although the movement can usually be anticipated correctly 6 to 12 hours in advance. At present, hurricane warnings are based on tracking of the hurricane movement and short range extrapolation of past movement. Improvement in hurricane warnings in recent years has been primarily the result of improvement in methods of tracking, and in extension of observing facilities to include a dense network of land stations and a large number of ship reports. Improvement of tracking methods has included use of radar for short range tracking and hurricane reconnaissance aircraft for tracking hurricanes outside of radar range, rapid and reliable communications, use of automatic weather stations on certain locations in the Bahama area, use of LORAN for navigational fixes on aircraft flying in the vicinity of the storm, and the use of aircraft radar for fixes on the storm center, and other facilities which are of general use in routine forecasting or are still in the research stage. The hurricane warning

service now in operation in the southeastern United States is a joint project of the U. S. Weather Bureau, the Air Force, and the Navy. All hurricane advisories, whether issued by the Weather Bureau or private meteorological consultants, are based on data procured by this joint governmental service, and the accuracy of such advisories is initially dependent on the effectiveness of the facilities provided for obtaining data.

The forecasting procedure for hurricanes consists of fixing the center by analysis of all available data and the prediction of movement by use of extrapolation of past movement, knowledge of wind, pressure, and moisture conditions in the upper atmosphere, and application of knowledge gained in the past of the characteristics of hurricane movement. Because of the extreme danger of the hurricane and the desirability of securing offshore work in anticipation of hurricane conditions one of the most important functions of a weather service for the offshore operations is in assisting in arriving at a decision as to when offshore rigs should be evacuated.

THE FORECASTING ORGANIZATION

To apply the foregoing forecasting techniques efficiently, assure accurate observations at the forecast location, and make use of radar in providing short range warnings the forecasting service is organized to include a forecasting unit in New Orleans serviced with Weather Bureau teletype facilities, and a meteorologist on full-time duty at the Grand Isle District office, who is equipped with meteorological instruments, a wave gauge, and radar. He is furnished twice daily, from the New Orleans office, weather information which permits an evaluation of local weather conditions in terms of large scale conditions over the United States and Gulf-Caribbean area. The meteorologist in the district office handles the distribution of forecasts, maintains complete weather observations, provides routine maintenance of meteorological instruments, and assists the district personnel when decisions must be made which call for interpretation of the forecasts or require information not included in the forecast. This latter function is quite important because the ultimate goal of the weather service is to anticipate working conditions, not weather conditions. The weather conditions must be interpreted in terms of how they will influence the operations and this interpretation can be carried out most effectively by discussion between the meteorologist and the district personnel.

UTILIZATION OF FORECAST IN OFFSHORE WORK

After the preparation of the forecast and the briefing of field personnel who will make use of the information, the next problem is to determine whether a particular transportation, drilling or production operation is feasible under forecast conditions. It is not possible to define operating limits without actual experience under various sea and wind conditions because the type of operation that can be successfully and safely carried out under forecast conditions depends on the type of equipment involved, the experience of the personnel engaged in the operation, and the length of time required to complete the work.

The transportation phase of offshore drilling and producing operations is obviously the most critical from the standpoint of sea conditions. The importance of forecasts in scheduling open sea transportation depends to a varying degree on the following factors: (1) distance to be traversed in the open sea, (2) length of time required for round trip, (3) seaworthiness of equipment involved, (4) nature of cargo, (5) facilities for mooring in open sea or at destination, (6) number of drilling and production operations under way simultaneously, and (7) proximity of operations relative to each other. When sending deep-draft tugs over shallow outside bars or in shallow channels, wave height forecasts are important in determining the possibility of the vessel pounding bottom or running aground in heavy seas. Sea conditions also greatly affect the speed at which a barge can be towed as well as the number of tows which can be successfully handled by a single tug. After the tow has reached its destination, wave and wind conditions determine whether or not it can be moored at the drilling or production site. A knowledge of expected wave conditions may dictate the necessity of having a tug stand by the tow at the drilling or production site in case of unfavorable weather.

Producing operations, where barging is the primary source of transportation, depend almost entirely on favorable sea conditions. To obtain as nearly as possible an uninterrupted flowing schedule, a forecast of sea conditions is important in order to make the most efficient and safe use of barges and tugs. A hazardous condition exists if a loaded barge of oil is caught in rough seas. There is danger that the barge will break loose from its mooring or its towing line and be set adrift. If loading or unloading operations are under way when wave heights increase, damage to the loading facilities, pollution of the water, or fire may be the result.

Forecasts of weather and wave conditions are important when long strings of casing are to be run. This operation to be successful must not be interrupted for any great length of time. Knowledge of expected sea conditions becomes even more critical when small platforms are used which do not contain sufficient pipe racks to hold the entire casing string. The job may be unsuccessful if it is necessary to remove the drilling tender due to rough seas when the string is being run. To minimize this hazard the amount of time required to lay down the drill pipe and run the casing string can be estimated and if unfavorable weather conditions which might interrupt the casing job were forecasted, the operation can be postponed to good advantage until more favorable conditions are expected.

During hurricane periods coordination between the meteorologist and the field personnel permits the continuance of drilling for a maximum period compatible with safety and resumption of work immediately after the danger is over. As a rule, evacuation of the offshore structures will require removal of drill pipe from the hole, movement of unpropelled vessels to hurricane anchorage, evacuation of personnel from rigs and anchored vessels by crew boats, and possibly evacuation from shore bases if storm tides are expected. This hurricane procedure is time con-

suming and may only be feasible under daylight conditions. After determination of the time required and conditions under which the evacuation must be carried out the meteorologist can assist in determining when the evacuation must be commenced to be completed under safe wind and wave conditions. Occasionally the initial movement of a hurricane may demand immediate preparations for evacuation while a later change in course may permit resumption of work although the hurricane is still active. Under these conditions the meteorologist's advice may be instrumental in avoiding costly downtime.

The foregoing examples indicate the types of situations in which the meteorologist can be of assistance in reducing the hazards and increasing the efficiency of the offshore work. The long-term utility of the present wave and weather forecasting service provided to the Grand Isle District can only be defined after a further period of test. Experience to date has justified extension of the period of test beyond the one-year period originally planned. ★ ★ ★

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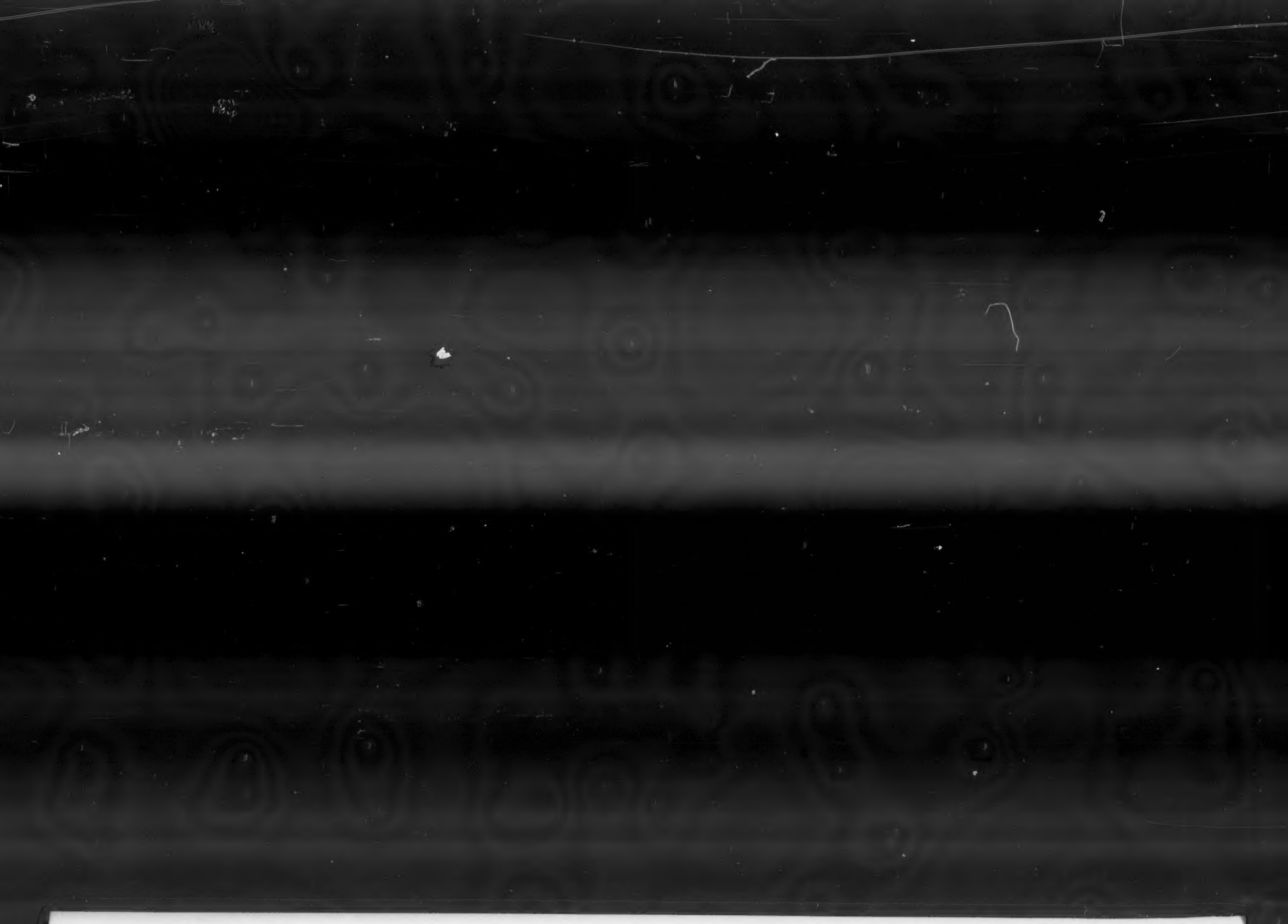
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